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NEXT MONTHLY MEETING, APRIL 14, 1908

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PROCEEDINGS

APRIL 1908

SPRING MEETING, JUNE 23-26, DETROIT, MICH.

APRIL 1908 VOL. 30 No. 4

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
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PROCEEDINGS
OF
THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

VOL. 30 APRIL 1908 NUMBER 4

THE next monthly meeting of the Society will be held in the Engineering Societies Building on Tuesday evening, April 14. The subject is the "Conservation of our Natural Resources," which has recently assumed so great prominence through the action of President Roosevelt in inviting the governors of the several States and the presidents of the national engineering societies to a conference in Washington in the month of May, to consider ways and means for the conservation of our resources.

The April meeting will be addressed by four speakers of wide reputation, who will give a general presentation of the situation as related to the sources and extent of our present supplies. The subject of deforestation will be treated by a representative of the department of forestry, whose talk will be illustrated by the government lantern slides. Fuels and water power will also have a presentation. The last address will be by Dr. Henry S. Pritchett, President of the Carnegie Foundation, who will speak upon the obligations of the engineer, who directs the use of nature's great stores of lumber, fuels and minerals, taking as his subject "The Engineer as Related to the Body Politic."

This will be the most important and far-reaching in its consequences of any of the monthly meetings held by the Society. An array of facts will be marshaled, which should arouse in every engineer a feeling of personal responsibility that he do his utmost in forwarding this great movement, in which his training and experience fit him to take a leading part.

It is expected that the four national engineering societies, and the engineering profession generally, will coöperate in this work and the position of this Society is expressed by the following resolutions passed at the March meeting of the Council in response to the letter from President Roosevelt published in the last Proceedings, asking for our coöperation and representation at the conference by President Holman.

WHEREAS, an invitation has been received from the President of the United States, asking the coöperation of this Society and its participation in the conference to be held in Washington, May 13 to 15 next, to discuss the conservation of the natural resources of the country:

Resolved, that the Council unanimously accept this invitation on behalf of The American Society of Mechanical Engineers and heartily undertake to coöperate with the President of the United States and with other engineering societies in furthering this important movement.

Resolved, that the executive committee of the Council be empowered to formulate at once a plan for such coöperative action and that the official representatives of the Society be authorized to take part in conferences with the representatives of the other national engineering societies, with a view to complying with the suggestion of the President of the United States.

Resolved, that the Secretary be directed to communicate this expression of the Council to the President of the United States and to the other societies concerned.

It is evident that the final responsibility for the successful outcome of this movement must rest with the engineering profession and the Council urges the membership to send to the Secretary suggestions and plans for the effective execution of the above.

THE SPRING MEETING AT DETROIT

Features that will contribute to make the Detroit meeting of unusual value professionally, and of much more than ordinary interest to both members and guests, are the conventions at the same time in that city of the Society for the Promotion of Engineering Education and of the Society of Automobile Engineers.

The Detroit meeting will open on the evening of June 23 and end Friday afternoon, June 26. The sessions of both the Society for the Promotion of Engineering Education and the Society of Automobile Engineers will be toward the latter part of the week, after the main sessions of our convention.

The program will be arranged to allow members interested in subjects at the sessions of the other societies to attend those sessions, without missing papers on similar or related subjects read before their own society. On this account the arrangement of the program can now be only tentatively announced.

As planned by the Meetings Committee, there will be a short but important professional session on Tuesday evening, followed by an informal reception. On Wednesday morning and afternoon there will be professional sessions and in the evening a lecture of general interest to both members and guests. Thursday morning will be devoted to the presentation of papers. On Thursday afternoon there will be an excursion and on Thursday evening will be the main reception.

It is probable that opportunity will be given for a trip to the University of Michigan at Ann Arbor. The Society for the Promotion of Engineering Education are to visit Ann Arbor and plans are contemplated for a joint session at the University.

Meetings will also be held by the Gas Power Section of the Society, arranged as far as possible so as not to conflict with the other sessions.

The papers for the Detroit meeting cover a wide range, including a symposium on the conveying of materials, an important subject in all industrial work, and papers relating to automobile construction, gas power, fuels, combustion and the use of steam. The late date at which this meeting is to be held will enable those connected with engineering schools to attend in larger numbers than heretofore at the Spring meeting, since in most cases their commencement exercises will be over before the meeting convenes.

DINNER IN HONOR OF THE PRESIDENT OF THE SOCIETY

President Holman was the guest of honor at a dinner given by the Missouri Athletic Club in St. Louis on Saturday evening, March 7. Mr. E. E. Wall, vice-president of the club was toastmaster, Mr. W. A. Layman responded for the Engineers Club of St. Louis; Mr. Robert Moore for the Civil Engineers; Col. E. J. Spencer for the Electrical Engineers; Dr. C. M. Woodward for Washington University. The dinner closed with an address by President Holman.

Informal addresses were made by Mr. B. H. Colby, Consulting Civil Engineer, Ex-Sewer Commissioner of St. Louis and a former associate of Mr. Holman on the Board of Public Improvements; Col. S. Bent Russell, Chief Engineer of the Louisville Water Company; and Mr. R. S. Colnon, who were associated with Mr. Holman in the water department of the City of St. Louis.

The Dinner Committee consisted of Messrs. William H. Bryan, chairman, J. A. Laird, and Edward Flad, members of this Society and of the Engineers Club.

The following members of the Society were present: Messrs. J. H. Ames, P. DeC. Ball, F. E. Bausch, Wm. H. Bryan, Edw. Flad, J. C. Higdon. A. W. Higgins, M. L. Holman, V. Hugo, J. A. Laird, G. W. Lillie.

MARCH MEETING

The monthly meeting for March, held in the Engineering Societies building, was well attended and the paper "The Steam Path of the Turbine," by Dr. Charles P. Steinmetz, was followed by a spirited discussion and an equally vigorous and forceful reply by the author. Although the paper was of a highly mathematical character, the subject was treated in a clear and varied manner and the audience was deeply interested to the end.

The Society was fortunate in having Professor Breckenridge, Vice-president of the Society and Professor of Mechanical Engineering of the University of Illinois, for its Presiding Officer. Not only was Professor Breckenridge particularly happy in his manner of presiding and in the atmosphere of freedom which he gave to the meeting, but his presence in the chair emphasized the national character of the Society organization.

It is interesting to note also that none of those who spoke at the meeting was from New York City. They came from Schenectady, N. Y., Pittsburg, Philadelphia, and from New Haven, Conn., while a contributed discussion was sent from Boston.

MONTHLY MEETING OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Members of the Society, in company with the members of the other national engineering societies, were invited to the meeting on March 5 of the American Institute of Electrical Engineers to hear an address by the Hon. Gifford Pinchot, Forester of the Department of Agriculture.

Mr. Pinchot presented the general problem of the conservation of our natural resources, dwelling upon forestry only in its relation to the other resources of nature essential to the continued prosperity of our country.

The main point he desired to bring out was the necessity for the engineer to take the lead in this matter and because he has the greatest information on the subject he is the more responsible. The people

have been thinking only of present success and expansion; now they must provide for stability of the country's greatness.

Previous to the meeting a luncheon was given at the Engineers' Club in honor of Mr. Pinchot, by the President of The American Society of Civil Engineers, Mr. Macdonald. To this luncheon were invited the President and Secretary of each of the Founder Societies.

THE SOCIETY REPRESENTED AT THE ANNUAL DINNER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

The annual reception and dinner of the Boston Society of Civil Engineers was held at the Hotel Vendôme, Boston, the evening of March 10. This Society was invited to be represented and as it was impossible for President Holman to attend, Mr. Fred J. Miller, Vice-President, was asked by the Council to do so.

About two hundred and seventy-five engineers were present and the addresses given after the dinner dealt largely with the relation of the engineer to public service and public duties.

Mr. Miller, on being introduced by President Howe of the Boston Society of Civil Engineers, referred to the varied character of their membership, which consists of all kinds of engineers; not only mechanical, but civil, electrical, mining and others. He said the various fields of engineering gradually blend from one to another. Engineering does not consist of a number of distinct compartments that are air-tight and water-tight, after the manner of a modern ocean steamer, and engineers are not separated from each other by walls of steel. While it is not desirable that the various engineering organizations should amalgamate, it is desirable that they should coöperate; and he referred to the Engineering Societies Building, New York, as affording an opportunity for different organizations to become—not consolidated—but neighbors, so to speak, as engineers ought to be.

Mr. Miller then dwelt upon the engineer as a citizen, as bearing upon the topic of the evening. The inclination and education of the engineer have been in the direction of fitting him to do things beneficial to mankind and to do this in a way that is perfectly straight; to return to society far more in value produced than he himself absorbs.

The engineer lives by showing people how to do new things in new ways and thus exerts a potent influence upon social conditions. His work has a far-reaching influence upon our manner of life and he

should appreciate that it may bring about new civic as well as technical questions that he must be prepared to meet. The engineer abhors and fears unbalanced structures and history shows that unbalanced social structures are more to be feared than unbalanced engineering structures.

MR. WOODBURY REPRESENTS THE SOCIETY

Mr. C. J. H. Woodbury of Boston, Mass., was appointed Honorary Vice-President to represent the Society at the National Conference on Standard Electrical Rules, held Friday, March 27, at 1 o'clock, in the auditorium of the New York Edison Company, at 44 West 27th street, New York. At this meeting the rules approved by the Underwriter's National Electric Association at its meeting were to be reviewed, and the effect these rules may have upon all interests considered.

AMENDMENT TO BY-LAWS

In accordance with the provisions of C59, at the meeting of the Council, February 14, it was proposed to add to the present By-Laws the following:

The Research Committee shall consist of five Members, Associates or Juniors. The term of office of one member of the committee shall expire at the end of each annual meeting.

This committee shall have supervision of such research or investigations as may be directed or approved by the Council; shall correspond and collaborate with committees of kindred technical, scientific or other societies; shall keep in touch with researches conducted in other countries, which are of value to the engineer, and shall report the same quarterly to the Council.

The committee will be expected to maintain a system of announcement of results of research, and the trend of investigations, in any field, which will be of value to the engineering profession.

Gifts or bequests to the Society for the conduct of research or investigation shall be expended under the direction of the Council and shall be kept separate from other Society funds.

These amendments embody the final and approved report of the committee appointed by the Council to frame By-Laws for the government of a Research Committee provided under C45 of the Constitution.

The Secretary hereby reports to the membership that the above amendments to the By-Laws were ordered and approved by the Council at its meeting March 10.

A GIFT TO THE LIBRARY

Mrs. Annie M. Forney has graciously presented to the Library the books on engineering collected by her husband, the late Matthias Nace Forney, who became a member of the Society the first year of its organization.

The collection includes 158 books on general engineering subjects, 19 handbooks, many volumes of transactions of engineering societies and bound volumes of periodicals. A complete list chronologically arranged will be found among "New Books" in this issue. There are also portraits of George Westinghouse, Charles R. Johnson and Howard Fay, and a photograph of a Baldwin locomotive.

By means of such gifts as these the usefulness of the Library to the engineering profession can be most effectively increased and the Society wishes to acknowledge the thanks it feels are due to Mrs. Forney.

Among the books in the collection is a copy of Galloway's treatise on the steam engine, edition of 1830, containing what is generally believed to be the first entirely complete account of the locomotive trials at Rainhill in 1829 when Stevenson's Rocket carried off the prize. This book also contains illustrations and descriptions of some of the earliest forms of steam vehicles for use on common roads.

Another valuable work is the report of the Committee to the House of Commons in 1831 upon steam carriages, including the complete discussion before the House, this being the official reprint made for the United States House of Representatives in 1832.

There is also a copy of the report to the House of Representatives by the Treasury Department in 1838 upon the use of steam engines in the United States and the accidents and injuries resulting from them.

Prof. Walter R. Johnson's report on American coals is also in the collection, as well as a copy of Reuleaux Kinematics, Professor Kennedy's translation of 1876, which has been out of print for a long time and is quite difficult to obtain.

Among the Proceedings of professional societies included in the above list are volumes which aid in completing the partial sets already in the possession of the Society.

One work of distinct personal interest in the collection is a copy of Mr. Forney's own book, the Catechism of the Locomotive, containing his own manuscript corrections. There are also several editions of the Car Builders' Dictionary, in the preparation of which he took

an important part, so that the collection is distinctly representative of his work.

The packages of pamphlets and photographs refer to important investigations in railroad and locomotive engineering matters in which Mr. Forney took an active part and which he directed to be preserved on account of their historic value. A detailed review of these will be given hereafter.

NECROLOGY

GEORGE WARREN HAMMOND

George Warren Hammond was born at Grafton, Massachusetts, April 4, 1833, and died at Yarmouth, Maine, January 6, 1908.

He was educated at Cambridge, Massachusetts, and in 1900 received the honorary degree of A.M. from Bowdoin College.

He began his career in a mercantile establishment at Long Wharf, Boston, and was subsequently imployed in a wholesale dry goods store. In 1854 he went to the Cumberland Paper Mills near Portland, Maine, and after a few years became manager. During this time he increased the capacity of the works many times, making a large success of the enterprise.

He resigned from the Cumberland Mills and entered the Massachusetts Institute of Technology as a special student on the chemistry of paper manufacture. In 1876 be became manager of the Forest Paper Company at Yarmouth, Maine. This mill was a pioneer in the manufacture of soda pulp and Mr. Hammond introduced many economies in this line of paper manufacture.

He retired from active business January 1, 1906.

Mr. Hammond had great ability as an organizer of industrial establishments, was a strong believer in the training of young men, and was one of the originators of what is now known as "welfare work" which provides the most favorable conditions for the housing and care of his help.

He served in the Maine Legislature from 1868 to 1870, was a member of the Maine Board of Agriculture, and also took active part in the collection and publication of Maine vital statistics.

He was interested in botany and mineralogy and was a member of the Visiting Committee of the Botanic Gardens and Herbarium of Harvard University from 1888 until his death. He was a member of the Congregational Church and of the Trinity (Episcopal) Church of Boston.

In educational matters he was trustee of the Gorham Academy, President of the Board of Trustees of the North Yarmouth Academy, Chairman of the Trustees of the Merrill Memorial Library at Yar-

mouth, Maine; Trustee of the Thatcher School Associates, Westbrook, Maine, and held numerous local offices in the two Maine towns where he lived. He was 32d Degree Mason, and in addition to membership in this Society, was a member of the American Pulp and Paper Association, American Association for the Advancement of Science, Society of Chemical Industry, London; American Institute of Mining Engineers, Society of Arts, Boston; Franklin Institute, Philadelphia; Massachusetts Historical Society, Horticultural Society, New England Historical and Genealogical Society, Bostonian Society.

While a man of force in the administration of the great manufacturing responsibilities under his charge, his personal life was that of a student, and he devoted himself to study and special investigations.

JAMES POWELL

James Powell was born in Ghent, Belgium, in 1832 and his parents came to America during his childhood. In 1846 he began the work of brass manufacture at his father's factory in Cincinnati, Ohio. This business was the founding of the manufacture of plumbers brass goods in the West.

An interesting item in the records of Mr. Powell's early business was an order from the Union Army during the Civil War for one thousand pairs of spurs of a special pattern to be delivered in 48 hours. There were no castings on hand and patterns had to be made, but the goods were shipped within two hours of the stipulated time.

In 1886 the business was merged into a stock company with Mr. Powell as president and manager, and he held this office until his death.

Mr. Powell invented many devices, among which patents were secured on globe valves, blow-off valves, lever throttle valves, improvements on lubricators, glass engine oilers, grease cups, injectors and devices for trimming engines and boilers.

Mr. Powell wrote frequently for magazines and journals, and was a reader and student.

He was a member of the National Geographic Society, the National Association of Manufacturers, Manufacturers' Club of Cincinnati, the Queen City Club; the Business Men's Club of Cincinnati and other business and philanthropic societies. He was an active worker in the Baptist Church, being a trustee and deacon for about forty years.

Mr. Powell died February 25, 1908.

SAMUEL WEBBER

Colonel Samuel Webber died at his home in Charlestown, N. H., on February 23. He was born December 9, 1823.

At 18 years of age he entered the employ of the Merrimac Manufacturing Company at Lowell, Mass., there developing the etching process for engraving rolls, and familiarizing himself with the operations of cotton manufacturing. He also assisted Dr. S. L. Dana in his experiments with boilers and fuel combustion. In 1847 Mr. Webber went to Lawrence, Mass., as draftsman and assistant engineer in building the former Bay State Mills. He was superintendent of these works in 1849–1850. In 1850 he was sent to Europe to study worsted and linen manufacture and to note the improvements in cotton machinery. While in London in 1851 Mr. Webber acted as one of the jurors on manufacturing machines and tools at the Crystal Palace, Hyde Park. Returning to this country in 1852 Mr. Webber set up a series of worsted machines in Lawrence and conducted extensive experiments with them. In 1853 he went to New York and arranged the exhibition in Reservoir Square, acting as commissioner of juries. In 1854 he went to Springfield, Mass., and finished building a cotton mill at Indian Orchard, installing the machinery and operating it for four years as the Ward Manufacturing Company. In 1858 he went to Manchester, N. H., as manager of the Manchester Print Works, remaining there until 1864, when he resigned to take charge of the Portsmouth Steam Mill, manufacturing spool cotton. While there Mr. Webber in company with J. S. Davis of Holyoke, Mass., and Phineas Adams of Manchester, N. H., called the first meeting for the formation of the New England Cotton Manufacturer's Association. Early in 1861 he was commissioned colonel and aid-de-camp on the staff of Governor Berry of New Hampshire and was commissioned to equip and command the First New Hampshire Light Battery in May, 1861. Colonel Webber went to Washington with this battery and the Fourth New Hampshire Infantry in October, 1861, and turned over the troops to the United States government.

In 1865 Colonel Webber did a large amount of engineering work during the autumn and winter for the owners of the water power at Bellows Falls, Vermont, measuring the flow of water there. In 1870 he collated the returns of the industrial division of the census at Washington. In 1871 he took up the question of the measurement of power, measuring by dynamometer the power used by cotton and other machinery, indicating steam engines, testing turbines, measuring waterflow,

examining water privileges and acting as expert in power cases in court. Colonel Webber was one of the judges of the cotton and cotton machinery group at the Centennial Exhibition at Philadelphia and prepared many of the reports and data. He was one of the judges at the Atlanta Exhibition in 1880. He was the author of many technical articles and he also wrote many interesting sketches of outdoor life which have been published in Forest and Stream, and other magazines.

ANNOUNCEMENT

Under the direction of the Council the Committee on Society History has arranged to present the results of its investigations to the members of the Society.

The Preliminary Report will appear in the Proceedings of the Society from month to month, and thus enable the matter to be open to comment during its completion. It is especially desired that any member who may be in the possession of facts or information bearing upon the various points as they are thus made public will communicate with the committee, in order that the final and completed report may have the advantage of the collaboration of the membership at large.

HISTORY OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Preliminary Report of the Committee on Society History

Chapter II—Continued

46 At the second annual meeting an important discussion took place regarding the general publication of papers presented before the Society. In the original Rules it was provided, in Article 40, that the Society should hold copyright of all papers, except by special agreement between the Council and the author, with the provision that the author should not be deprived of the right to give copies of his papers for publication in any reputable journal; the Society not being responsible for any such unofficial publication.

47 An amendment to Article 38 of the Rules had already been offered at the Hartford meeting requiring the Secretary to submit proofs of papers to authors and to the membership so far as possible. This amendment was brought up at the Altoona meeting, in August 1881, and carried. This was practically the beginning of the plan of sending out advance papers for each meeting.

48 At the Altoona meeting another amendment was presented by Dr. James C. Bayles, bearing upon Article 40. This amendment

provided that the Secretary should have printed copies of papers for distribution to the press at the time of reading, but that the author should be considered as having withdrawn his paper from the Society if he allowed it to be published prior to its presentation at the meeting.

49 An animated discussion upon this matter occurred at the second annual meeting in New York, showing that at that period in the development of the Society its papers were already sought as valuable material by the technical journals, and that some definite arrangement was necessary by which the Society might provide full opportunity to its members to give their work the wide publicity thus attainable without at the same time anticipating the appearance of their work at the meetings.

50 Although it developed at this discussion that it was the desire that the widest possible publicity for papers presented at the meetings be encouraged, the amendment was lost; and Dr. Bayles gave notice that he would present it again for consideration at the next annual meeting.

51 All of this discussion showed that the practice then in vogue of presenting papers in manuscript at meetings without giving the membership opportunity to examine them beforehand, was by no means satisfactory, and that there was a disposition to remedy this defect, aided by the technical press, through the efforts on the part of the various journals to secure the most desirable papers at as early a date as possible and so get ahead of rival publications. It was thus really an encouraging sign of the interest in the work of the Society, and of the part which it was already beginning to fill in the field of engineering. The entire discussion, as it appears in the Transactions of the second annual meeting, is both instructive and interesting.

52 Another matter of importance was brought up at the second annual meeting, one which has received a satisfactory solution only within recent years. Under the original rules the papers presented to the Society were to be submitted to the Council for approval and acceptance, and after presentation, the Council had the authority to direct that the papers be printed.

53 At the second annual meeting a paper was presented, read, and discussed, and directed to be printed, but this latter action was reconsidered at the same meeting, and action taken that the paper be referred back to its author, with instructions for him to present additional facts regarding the experiments upon which the paper was based. The result of the discussion was that the paper was accepted, and was published in the Transactions. This cumbersome method

of dealing with such cases was not wholly obviated until the work was divided, much later in the history of the Society, between two standing committees, one, the Committee on Meetings, whose duties were to procure papers and print them in advance issue, the other, the Publication Committee, whose duties were to edit them for subsequent appearance in the Transactions, this latter committee having power to select from the material such as it should decide to be suitable for permanent preservation in the Transactions, and to omit any matter not deemed desirable for publication.

54 Between the dates of the second annual meeting, in November 1881, and the spring meeting of 1882, the Society met with a great loss in the death of Alexander L. Holley, who passed away on January 29, 1882. Since Mr. Holley had been a member of the American Society of Civil Engineers, and the American Institute of Mining Engineers, as well as of The American Society of Mechanical Engineers, action was taken by all three organizations, a joint committee meeting in New York on March 22, 1882, and arranging for a united memorial session, and also discussing the practicability of erecting some kind of a monument to his memory. In the catalogue of the Society, issued at the beginning of 1882, there were placed, by direction of the Council, the names of Henry Rossiter Worthington, and Alexander Lyman Holley, at the head of the list as Honorary Members in Perpetuity, Deceased Founders of the Society, where they have remained in each succeeding issue of the catalogue.

55 The first regular meeting of the Society for 1882 was held in Philadelphia, April 19 to 21, the sessions being held in the lecture room of the Franklin Institute. Although the principal business matters of the Society are reserved for the annual meetings, there were some important questions brought up to which attention may properly be called.

56 The incorporation of the Society was formally announced as an accomplished fact; a committee appointed to aid the other national societies in effecting the restoration of the United States Commission of Tests of Metals and other Constructive Materials, presented a report, and a memorial session was held upon the death of Mr. Holley.

57 Another matter came up in a form which makes it an interesting anticipation of what has so recently become a reality, the erection of a Union Engineering Building for the several national societies.

58 From the time of its formation the business headquarters of the Society had been at the office of the Secretary, at 239 Broadway, New York.

59 There was now appointed a Committee on Permanent Location, this committee having in charge the question of the provision of a building for the Society. In his introductory remarks at the opening of the meeting, the President, referring to the work of this committee, said:

The Society of Civil Engineers has a house in New York, which it now owns.[1] The Institute of Mining Engineers has no headquarters, and it is at a great disadvantage for that reason, and it is the hope of members of those two societies and of this Society, with whom I have talked on the subject, that in the course of time the three may unite in putting up a building, probably in the city of New York, which will be the headquarters of the members in the city. That being done it will form the center for the engineering interests of the whole country. That is the scheme which the Committee on Permanent Location has in hand.

60 It is interesting to note that at the time this suggestion was made the American Institute of Electrical Engineers had not yet been founded, and that it was not for 25 years that the dream of a Union Engineering Building became a reality.

61 Another plan then mentioned for the first time, afterward to be realized, was that of a trip to Europe, a joint committee of the Civil, Mining and Mechanical Engineers having this under consideration. This idea, largely the proposal of Mr. Holley, naturally languished after his death, and the committee reported that the times were not yet ripe, so that it was indefinitely deferred. How effectively it was afterward realized the records for 1889 and 1900 will show.

62 The Holley Memorial Session, held on the afternoon of April 19, 1882, is fully reported in the Transactions of that year. Addresses were made by the President of the Society and by Dr. Bayles, and responses by Mr. Fernie, Mr. Coxe, Mr. R. W. Hunt, Mr. Metcalf, Mr. Porter, Mr. Hoadley, Mr. Coleman Sellers, and others.

63 The tribute was one such as is rarely given to a man whose career has been spent among the stern realities of steel and iron, of force and motion, and it might be well if the members of today would occasionally turn back to vol. 3 of the Transactions of the Society and read what its members had to say to each other about the man who did so much to bring the organization into being. It may be well in this connection here to add the words which he himself spoke but a short time before his death, at a meeting of his associates in Pittsburg:

[1] This refers to the house then occupied by the American Society of Civil Engineers at 127 East 23d street, New York.

Among us all who are working hard in our noble profession, and are keeping the fires of metallurgy aglow, such occasions as this should also kindle a flame of good fellowship and affection which will burn to the end. Burn to the end! Ah! well, may it so happen to us that when at last this vital spark is oxidized, when this combustible has put on incombustion, when this living fire flutters thin and pale at the lips, some kindly hand may "turn us down," not "underblown"—by all means not "overblown"—some loving hand may turn us down that we may, perhaps, be cast in a better mold.

64 The joint memorial session was held in New York in connection with the annual meeting of 1882, and the address delivered by Dr. R. W. Raymond will be found in connection with the report of that meeting. The memorial, for which subscriptions were made by members of the three national societies, took the form of a bronze portrait bust, which now stands in Washington square, in New York.

65 At the Philadelphia meeting a point was raised which has since governed the action of the Society in a number of instances, and is now incorporated in its Constitution. In the discussion of a paper upon standard gages it was suggested that the Society should in no case *adopt* anything, but that it should simply publish the reports of its committees, the results of its investigations, and the like, and thus give the information to the world for public use. As a consequence of this precedent, the Society has never *adopted* any standard, or code, or any report of any kind, and has been careful to make this fact known, so that it is regarded as taking a higher ground, namely, that of laying the work of its members and committees before the profession to stand on its merits, rather than on any official endorsement. This precedent, brought out first at the Philadelphia meeting of 1882, is now crystallized into Article C56 of its Constitution, as follows:

The Society shall not approve or adopt any standard or formula, or approve any engineering or commercial enterprise. It shall not allow its imprint or name to be used in any commercial work or business.

66 The report of the Committee on the Tests of Materials of Construction took the form of a paper presented by Professor Egleston followed by a discussion, the paper including a memorial to be presented to Congress, urging the appointment of a commission

to plan and execute the needed investigations and tests upon materials used in the manufacture of machines, buildings, bridges, and other constructions, to deduce such rules from them as will lead to the greater safety of the structures, and economy in the use of the materials of which they are made.

67 The result of this report was the acquisition of a great number of signatures to the petition, which was subsequently presented to Congress, and which materially aided in the consummation of the desired result.

68 In this connection, it may be stated that the large testing machine at the Watertown Arsenal, used by the commission and acknowledged to be the highest example of this type of mechanism, was the invention and design of Mr. Albert H. Emery, a member of the Society.

69 At the Philadelphia meeting a paper was read by Mr. Frederick Fraley, himself not a member of the Society, but one of those who had founded the Franklin Institute in 1824, President of the American Philosophical Society, and one of the hosts of the Society at the meeting. Mr. Fraley's address constituted a review of the progress of mechanical science from the date of the founding of the Franklin Institute in 1824 to the date of the meeting in 1882, and as such it forms a valuable contribution to the work of the engineer. It was included in the published papers of the meeting, and appears in vol. 3 of the Transactions.

70 The annual meeting of 1882, held at the Turf Club theater, New York, opened, as has already been said, with the Holley memorial session, held jointly with the American Society of Civil Engineers, and the American Institute of Mining Engineers. The address delivered by Dr. Rossiter W. Raymond was an eloquent tribute to the memory of Mr. Holley, and was published in full in vol. 4 of the Transactions.

71 At the business session of this meeting the report of the Treasurer showed that a critical period in the history of the Society had been reached. The extension of the work of the Society, including the plan already put into practice of printing the papers in advance of the meeting, caused a natural increase in its expenditures, and the discussion turned largely upon the question of ways and means for the future.

72 The amendment, presented by Dr. Bayles a year before, concerning the printing of papers, was given animated discussion, and finally passed in an amended form, the conclusion of the amended Article 40 having the now familiar form:

> The policy of the Society in this matter shall be to give papers read before it the widest currency possible, with a view to making the work of the Society known, encouraging mechanical progress, and extending the professional reputation of its members.

73 At this meeting the general desirablity of revising the By-laws of the Society was discussed, and the Council was directed to appoint a special committee to undertake this work.

74 The report of the tellers of election announced the choice of Mr. E. D. Leavitt, Jr., of Cambridgeport, Mass., as President, and the reëlection of Mr. Charles W. Copeland as Treasurer.

75 The address of Prof. R. H. Thurston, the retiring President of the Society, may be compared with the address made by him at the close of his first year of office, since it shows again the state of several departments of the applied science of engineering at that date.

76 He mentions iron as being "fairly displaced by its younger rival, mild steel," and refers to the Forth bridge as one of the great engineering projects in contemplation. The development of the roller mill as a substitute of the buhr stone for the grinding of flour is mentioned as worthy of note, as well as the progress of the grain elevator system for handling grain.

77 Especially interesting, however, is the reference to what he termed "the last established branch of our profession, Electrical Engineering."

78 Speaking of this novel subject he says:

> We find ourselves still in the midst of a revolution, the progress of which we are all watching with unusual interest—the displacement of our older methods of supplying light and power by a new system, which but lately was but the toy of science, and which comes out of the least utilitarian of all branches of pure physics. Brush has set up his blazing sunlike arc lights in nearly every large city of the world; Edison has spread a network of conductors throughout the most densely settled parts of New York City, distributing many thousands of his clear mellow lights to send their soft white rays into corners never yet revealed by the feebler yellow light which they displace. It remains to be learned what is to be the cost of the new method of illumination; no figures that I consider wholly reliable have yet been given. It seems sufficiently certain, however that the arc light is much more economical than gas—the same quantity of light being demanded—for the illumination of streets, public squares and large interiors, while interior illumination by incandescent lamps is still generally more costly than any other usual method.

79 Speaking of progress in marine engineering, he refers to the fact that the record holder of the day, the Alaska, was "making 18 knots regularly, closely followed by the Arizona, and the Servia in this wonderful performance."

80 Although the original Rules provided for the election of Honorary Members, no election to that grade had been made until the third annual meeting, but at that time a number of names were

announced as having been chosen in the honorary list. These were all foreign engineers with the exception of Mr. Peter Cooper, of New York. Of the other Honorary Members then elected three, Messrs D. K. Clark, C. W. Siemens, and Sir E. J. Reed, were from England; four, Messrs. Hirn, Hallauer, Schneider and Tresca, were French; and two, Messrs. Clausius and Reuleaux, were German.

81 Among the papers presented at this meeting there may be mentioned that by Professor Lanza, recording the results of test made upon full sized spruce beams in the laboratory of the Massachusetts Institute of Technology, as well as a paper upon steam boiler inspection, by Mr. F. B. Allen.

82 The plan of having but two meetings each year having superseded the original number of three, the summer meeting of 1882 was the seventh regular meeting of the Society, and was held from June 12 to 14, at Cleveland, O., the sessions taking place in the City Hall. This was the first meeting held as far west as the Great Lakes, and the location itself is evidence of the widening interests of the Society.

83 As has since proved to be the case at the summer meetings of the Society, much of the activity of the gathering was due to the opportunities to visit local objects of interest. These included visits to iron and steel works and to the ore-handling equipment at the docks.

84 Among the important papers presented at this meeting were those of Mr. Henry R. Towne on cranes, and Mr. William Kent upon the evaporative power of bituminous coals. In the light of present progress much interest attaches to the paper of Mr. W. E. Ward, discussing the use of beton combined with iron as a building material, this constituting a very complete review of what is now better known as "reinforced concrete," and generally accepted as one of the most important modern methods of construction.

(To be continued)

GAS POWER SECTION[1]

GAS ENGINE AND PRODUCER GUARANTEES

By PROF. C. E. LUCKE, NEW YORK
Member of the Society

In negotiations between builders and purchasers of gas engines and producers it has been the custom to introduce a guarantee of performance expressly covering certain important items, such as horse power capacity, efficiency, fuel consumption per unit of output, degree of regulation, workmanship and material and items involving the general questions of their adaptability to service and reliability.

2 In the course of my practice it has been brought home to me rather forcibly that these guarantees are often so loosely written that they fail to express precisely what was intended, and what is more important, indicate the professional need for an accepted mode of procedure and interpretation of terms. In the short time permitted me to prepare this discussion I have not been enabled to present as many different forms of guarantees as I should like, but perhaps the following illustrations, clipped from some old contracts, will serve my purpose, which is more to call your attention to the need of action on this question than to present specific examples.

ENGINE CAPACITY

3 A statement of engine capacity involves a correct definition of the output of the engine in terms capable of being checked by test and in simple language that cannot be misinterpreted. A few examples will be given for illustration.

FORM A

This engine is to be capable of developing 100 b.h.p.

4 This would seem at first glance to be clear and definite, yet as a matter of fact it is not, because, first, the engine in question was

[1]The following papers and discussions were presented at the first meeting of the Gas Power Section on Tuesday evening, February 11.

direct connected to a generator and was without any means for determining the brake horse power, except by figuring back through the generator efficiency, which involved a calculation based on somebody's else data not verifiable; and second, it makes no provision for overload. Is the engine to be capable of delivering just 100 b.h.p, or is there implied in the common usage of the term "horse power" a certain excess? What is the length of run which determines the horse power capabilities of an engine? It might seem that if an engine gave a required horse power for one hour, it would be capable of doing so for two, three or four hours, or a week; yet, as a matter of fact, the engine, being new, might run hot at the end of the first hour. In that case, has the engine proved itself incapable of delivering 100 b.h.p.? Furthermore, there is no kind of gas specified. An engine which might deliver 100 h.p. on natural gas probably would not deliver over 80 h.p. on weak producer gas. There is no speed mentioned beyond the fact that in another part of the contract it reads that the engine speed shall be 100 r.p.m. If the brake horse power has been obtained satisfactorily with 90 r.p.m. has the engine failed?

FORM B

This engine, when running at the normal speed of 100 r.p.m. with gas containing 125 B.t.u. per cu. ft. will develop 900 b.h.p.

5 This would seem to be better, in as much as it fixes a certain speed and a certain calorific power, but as practically all the gases used as power fuels contain some hydrogen, there will be a difference between the calorific value by the calorimeter and the heat actually available in engines of this class with hot exhausts. The gas supplied might have a calorific power with the high value greater than that specified, and the low value lower. Has this engine then failed? Or has it fulfilled its guarantee? The time element for the run would seem to be covered in the following:

FORM C

We guarantee this engine to be capable of developing 500 i.h.p. for a period of three consecutive hours, at the specified rate of speed, operating on producer gas of good quality, manufactured by the Dawson gas producer, and containing not less than 125 B.t.u. per cu. ft.

6 Here the indicated horse power is specified, but in tests of such engines there will be differences in the indicator cards, often as great as 10 per cent, for which no provision is here made, and it becomes

a matter of arbitration to decide what is a fair average card. Furthermore, it is to be noted that in this, as in Form A, the capabilities of the engine are guaranteed and not the actual performance. It would seem that if an engine can show a certain mean effective pressure, and will run, it is capable of giving a certain horse power at a certain speed, whether it ever did so or not. There are also in Form C three definitions of the gas. It is to be good; it is to be the kind made by the Dawson producer; it shall have 125 B.t.u. per cu. ft. In an actual case, however, these may be somewhat contradictory.

7 The altitude at which an engine is to run will affect its capacity, as will also the pressure at which the gas is supplied, and the temperature of the gas. The following, Form D, is somewhat better in this respect than those preceding.

FORM D

The gas supplied to the engine is to be producer gas of approximately 125 effective B.t.u. per cu. ft., when figured at 62 deg. fahr., and 30 in. mercury, and shall be free from injurious amounts of tar, dust, sulphur, and other foreign ingredients. The gas is to be supplied to the engine at a pressure not exceeding one-half pound per square inch by pressure gage, and not less than four inches pressure by water column, and at a temperature not exceeding 100 deg. fahr.

Revolutions per minute at normal load, approximately 150.

Altitude above sea level, approximately 500 feet.

Under the above conditions the normal rating of the engine will be 500 b.h.p. The engine will, however, be capable of developing 15 per cent overload for a period not exceeding two hours.

8 The foregoing contains as an indefinite element the quantities of tar, dust, sulphur, etc., elements which are injurious, without defining how much of each shall be considered injurious.

PRODUCER CAPACITY

8 In what terms shall the capacity of producers be defined? Shall we rate producers in terms of horse power? Evidently not, because they do no work. It might seem proper to rate them in terms of the horse power of the gas engine that can be driven from the producer gas, but as the rate of gas consumption of different engines is different, this would make the capacity of a producer dependent upon the efficiency of an engine, which is obviously unfair. The real function of a gas producer is to gasify coal, and it might seem advisable to define its capacity in the quantity of coal it can gasify within proper limits, or in terms of the volume of gas, or the quantity

of heat it can produce in the form of gas. Such is the intention of the following, Form E.

FORM E

We guarantee this producer to be capable of gasifying 400 pounds of good quality No. 1 buckwheat anthracite coal per hour.

10 As this particular producer was operated by a steam jet blast, the coal consumed by the boiler should, in all fairness, be likewise specified. Furthermore, what is good quality No. 1 buckwheat anthracite coal, and for how many hours will the producer keep up its rate of production? The time element becomes important, because some producers will not run more than a few days without cleaning and others will continually get hotter and have to be relieved of load to cool off. There is, moreover, no provision in this form for overload or excess capacity. Form F gives a different mode of defining producer capacity.

FORM F

The producer is rated at 200 h. p.

Normal capacity, 20 000 cu. ft. of gas per hour.

Maximum capacity, 30 000 cu. ft. of gas per hour.

The producer is designed to operate on anthracite coal, coke or charcoal in sizes which will pass over a three-eighths inch screen. The gas leaving the producer will be cool, dry and free from injurious amounts of tar, dust and other foreign matter as required for gas engine purposes. It will have an approximate heating value of 125 B.t.u. per cu. ft. measured at 32 deg. fahr. and 30 in. barometer.

11 How free of injurious matter must a gas be as required for a gas engine? We all know that one form of engine is capable of operating with more dirt than another, and which one is here meant? How are the cubic feet of gas to be measured and at what pressure? Meters for this purpose are very costly, are proverbially inaccurate, and who should supply them in case they are to be used? The calorific power of the gas is not stated as the high or the low value, as pointed out in discussing the case of engine capacity, and the horse power and gas capacity may, in a test, conflict.

ENGINE EFFICIENCY

12 The guarantee of engine efficiency involves, in addition to the guarantee of capacity, one of input energy. The following forms,

G, H, I and J, are expressions having this end in view and are written after the subject of engine capacity has been guaranteed so that references to load imply that previously specified in these clauses.

FORM G

It is guaranteed that the above engine shall not require to exceed 10 000 B.t.u. per b.h.p. per hour on full load when running on Dawson producer gas and not to exceed 15 000 B.t.u. of the above gas when running on half load.

FORM H

The quantity of gas containing not less than 125 B.t.u. per cu. ft. consumed is guaranteed not to exceed 80 cu. ft. per i.h.p. developed per hour, or not to exceed the amount produced by the Dawson producer from one pound of best quality No. 1 buckwheat anthracite coal. The engine in each case operating under full load.

FORM I

We guarantee that the engine specified in the foregoing will produce the brake horse power stated, with a consumption of British thermal units in the form of gas, not exceeding 10 000 B.t.u. (low heat value) per b.h.p. per hour when operating at full load provided the gas contains no more than 14 per cent of hydrogen, 0.01 grams of tar per cu. m. and 0.03 grams of dust per cu. m. The British thermal unit value of the gas may range from 120 B.t.u. to 145 B.t.u, but should be kept as constant as possible.

FORM J

We guarantee that this engine shall develop the brake horse power when operating at full load with a gas consumption equivalent to 10 000 effective B.t.u. per hour, and at half load it will require 15 000 effective B.t.u. per b.h.p. per hour and the fuel consumption at intermediate loads will be proportionate.

13 In these forms for engine efficiency no radically new conditions are introduced, because the input energy of an engine involves the output of the producer, and the same elements of indefiniteness previously pointed out are here repeated. Does Form I imply that at zero brake horse power the heat consumption will be 20 000 B.t.u. per b.h.p. per hour? Evidently this must be infinity.

PRODUCER EFFICIENCY

14 The defining of producer efficiency involves, besides the output or capacity rating in terms of gas, or heat in the form of gas, its input energy in the form of coal; and perhaps steam, if it be a steam cooled producer. The following Form K is one very commonly met with.

FORM K

We will guarantee this plant, when operating on good quality No. 1 buckwheat anthracite coal, to deliver gas in quality and quantity equal to an average of 10-000 B.t.u. per pound of coal gasified in the producer. We guarantee this gas to contain 125 B.t.u.per cu. ft.

15 This fails to define the coal. It fails to define input energy in the form of steam or coal burned to make that steam; it also fails in providing for the measuring of the gas energy by cubic feet and British thermal units per cubic foot under proper limits. It is a good example of a guarantee that it is practically impossible to check by test because of the difficulty in measuring the coal in addition to the lack of gas meter pressure.

16 It may seem a simple matter to measure the coal fired to a producer in pounds per hour as fired, but it is not a simple matter to measure the coal gasified. Many producers contain a weight of coal and ash combined equivalent to over twenty hours regular supply. The problem of finding the coal consumed, or judging it from the coal fired, involves the determination of the condition of the bed before and after the run. In boiler practice it is usual to make a run of about twelve hours when coal measurements are involved. If it be assumed that the grate will contain at any one time as much coal as would be fired in one-half hour, this means that the length of run is 24 times as long as it takes to fire one grateful. If, in the producer, the bed contains 20 hours supply, or the equivalent of 20 hours regular firing, then the same degree of accuracy would require a length of run of 24 by 20 hours or nearly a month, which is never made.

REGULATION

17 It is often a requirement of regulation that it be good enough, or proper for the service, as for example in Form L.

FORM L

We guarantee that these engines will operate the herein mentioned generators (60 cycle alternator) in parallel without cross-current in excess of good steam engine practice.

18 Such a guarantee as this is very indefinite, and its fulfilment is more a matter of opinion than of scientific definition or test measurement. A more common form of regulation guarantee, in terms of per cent, is given in Form M, and a still more complete form of the same general clause is given in Form N.

FORM M

Between no load and full load the mean speed variation shall not exceed 3 per cent either way from the normal speed for all reasonable and usual changes of load. In case of unusual and sudden large changes of load the speed may momentarily exceed these limits, but will not exceed the limits of safety.

FORM N

The required regulation, under this contract, for each of the above engines, is that the total variation in speed, due to change of load shall not exceed the following percentages. From no load to rated load, not to exceed 5 per cent; from quarter load to rated load, not to exceed 4 per cent; from half load to rated load, not to exceed 3 per cent; from three-quarters load to rated load, not to exceed 2 per cent. When running on a continuous fixed load, the variation is not to exceed 1 per cent above or 1 per cent below normal speed. It shall be the privilege of the builder to require that the official test for determining whether each engine conforms to the above guarantee shall not take place before each engine shall have been in operation 30 days.

19 These last two forms are defective, in as much as there is not common acceptance of the meaning of the words "revolutions per minute" and the mode of measurement.

20 What is a usual change of load, and when is a change of load sudden? How long a time is implied in the word "momentary," and what is a limit of safety? These are all extremely indefinite and such lack of definition holds a possibility of dispute and law suits. How are the revolutions per minute to be determined? Are the revolutions to be counted for one minute or counted for five minutes and divided by 5, or counted for one-tenth of a minute and multiplied by 10? All of these modes of measuring will give different results for the revolutions per minute.

21 Perhaps I have said enough to make it clear that in some existing guarantees of gas engines and producers there is a deplorable lack of definiteness; a prevalent tendency to guarantee in terms of units that cannot be measured, or which are extremely costly to measure, or which may be measured in several ways without defining which one is implied.

22 Out of all this apparent confusion there are several simple and direct ways, and the selection of one as the solution of the problem is, first, a question of definition of terms with limiting conditions, and secondly, one of mutual agreement to accept such definition. Nothing would be easier than for me to answer these questions myself,

but to do so would defeat my purpose in raising the issue. It is the duty and privilege of this Gas Power Section of The American Society of Mechanical Engineers to give to the industry an answer based on mature judgment. I, therefore, lay this before you for consideration and discussion.

A SIMPLE CONTINUOUS GAS CALORIMETER

BY PROF. C. E. LUCKE, NEW YORK
Member of the Society

All heat engines in practical operation, when supplied with commercial fuels, may have their performance expressed in the pounds of coal, gallons of oil, the cubic feet of gas or other fuel units per horse power hour, but as the thermal value of the different specimens of any one fuel is not constant, such a mode of defining performance fails to give the thermal efficiency of the engine or plant and, in addition, and what is more important commercially, it is impossible to judge which is the cheaper fuel.

2 The high class steam plants and large consumers have come to the point of purchasing coal in heat units instead of tons, and their specifications contain a fixed price for one quality of fuel, based on its calorific power as found by systematic and regular calorimeter tests, and carry with this clause a bonus for exceeding a fixed calorific power and a penalty for failing to reach it. The coal in any one shipment will run fairly constant in calorific value, so it is only necessary in such tests that the calorific value of a fixed number of samples be taken to evaluate the lot in order to reduce the purchasing of coal to the basis of the purchasing of heat.

3 The coal calorimeter thus has been brought into use as a commercial measuring apparatus, as valuable in the daily work of the plant as the coal scales, and its sphere of usefulness has in consequence been extended beyond the more occasional efficiency tests of the coal fired plant.

4 In a similar manner the calorific value of a fuel gas fixes the output of the gas producer, the input energy of the gas engine, and the usefulness of public service and other gas supplies for such purposes as furnace heating, cooking and the production of light by all mantle methods. The gas calorimeter has found a useful place in tests of gas for such purposes, but as the calorific power of a gas may vary

widely and quite suddenly, such tests become of value only when made continuously, which is not possible with the ordinary intermittent instrument. And further, to be of commercial value in the purchase of heat in the form of gas instead of buying cubic feet of gas, it is necessary that the gas calorimeter be made automatic as well as continuous, or at least that it be continuous and operative by common unskilled labor. In the everyday operation of a gas power plant, involving the gas engine and producer, the daily performance of one cannot be separated from the other without such an instrument, nor can the engine and producer operator do more than guess at the proper adjustment and handling of their apparatus.

5 The general need of such an instrument that would be as necessary to the gas maker and gas user as the steam gage is to the fireman and steam engineer has been keenly felt and serious effort has been made to supply the need; but as the work of different investigators has never been published it is necessary to resort to the records of the patent office to show the nature of this effort; which has not as yet resulted in the placing of such instruments on sale.

6 Prof. Hugo Junkers of the Royal Polytechnicum at Aix-la-Chapelle, Germany, patented in this country March 10, 1896, the gas calorimeter in Fig. 1, which up to the present has been the standard instrument for the determination of the heating power of gases. The principle underlying the instrument is extremely simple and as most of the members are familiar with it, it will not be described much in detail here.

7 A gas burner of the Bunsen type liberates the heat of combustion of the gas. The hot products of combustion from this burner, together with any excess air that may have been admitted to the chamber containing it, pass vertically upward through a straight flue, under the ordinary draft influence of the heated column. They then pass downward through a number of small tubes surrounded by water which, in cooling them below the atmosphere, assists in the descent of the gases.

8 Adjustments are provided in the instrument, consisting of a water-controlled valve to regulate the quantity continuously flowing through, and different gas orifices for the burner, to accommodate different gases which may vary in calorific value from less than 100 to more than 1000 B.t.u. per cubic foot, to the end that the final temperature of the issuing products of combustion may be reduced to that of the atmosphere, it being assumed that the gas is supplied at the same temperature as the atmospheric air. With corrections for

radiation, this mode of procedure results in the giving to the water flowing through the instrument all the heat of combustion of the gases and none of the heat of the atmosphere which supports the combustion.

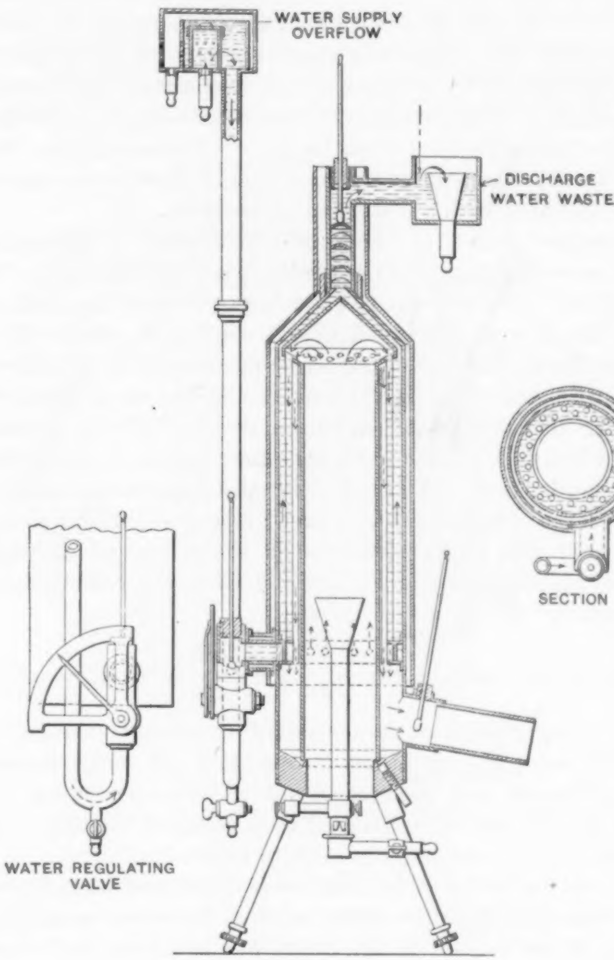

Fig. 1 Junkers Gas Calorimeter

9 An accurate wet gas meter is used to measure the amount of gas burned and a graduated liter jar, into which the discharging water can be directed at will, serves to measure the quantity of water simul-

taneously with the gas. A small gas holder is also provided to remove from the meter, so far as possible, the pressure fluctuation effects of the pipe line, permitting the gas to be measured at a constant pressure.

10 Wide fluctuations of gas pressure exist in ordinary working, especially in blast furnace plants, often varying from ten inches water pressure above to several inches below atmospheric pressure, without warning and in short periods of time. In such cases the gas supply is to be provided for by separate means, as must also be done when a suction producer, which is always under a vacuum, is under observation. The best method I have found of eliminating this variable pressure trouble has been an ordinary suction tee, discharging into a reservoir chamber with a water sealed overflow.

11 Another defect of the ordinary Junkers instrument that becomes somewhat serious with weak gas is the tendency for the gas to go out at the burner, due to the lifting action of the draft on the flame. This I have succeeded in overcoming in practically every case by placing a flat disk of copper about one-eighth inch above the burner outlet, and extending beyond the burner about one-half inch all around. The flame will then burn under the disk with no tendency to lift and is supplied with the proper amount of air on the under side.

12 A third defect, and probably the most important commercially, is that after the observations have been made of quantity of gas, quantity of water and temperature rise of the water, which require a reasonably skillful man and considerable time, the calorific power is only found by calculation as follows:

13 $$\text{B.t.u. per cu. ft. of gas} = \frac{\text{lb. of water}}{\text{cu. ft. of gas}} \times \text{temp. rise of water.}$$

The instrument therefore, though found extremely valuable in test work, fails under the conditions of operation previously mentioned, is not continuous, and therefore is not as valuable commercially as it might be. It cannot be handled by a common fireman in charge of a producer, and furthermore is quite expensive.

14 It was pointed out by Junkers in 1903, and later by several others independently, that if the ratio of the water supply to the cubic feet of gas burned in the same time could be kept constant, then the calorific power would be directly proportional to the temperature rise of the water. A patent was issued to Junkers in England in 1904 and on October 19, 1906, in the United States, ten years after his original patent, describing an instrument to maintain this proportionality and to record the differences in temperature, thus making

the instrument continuous and automatic. Fig. 2 shows what was proposed by Junkers to accomplish this result. To the gas meter there is now added a water meter and the two meters are geared together.

15 I doubt whether any water meter and gas meter can be made that will accomplish the desired result when one drives the other, or when both are driven from an outside source, until new principles in meter operation are discovered; and the additional meter adds to the expense. The rise in temperature of the water is found directly

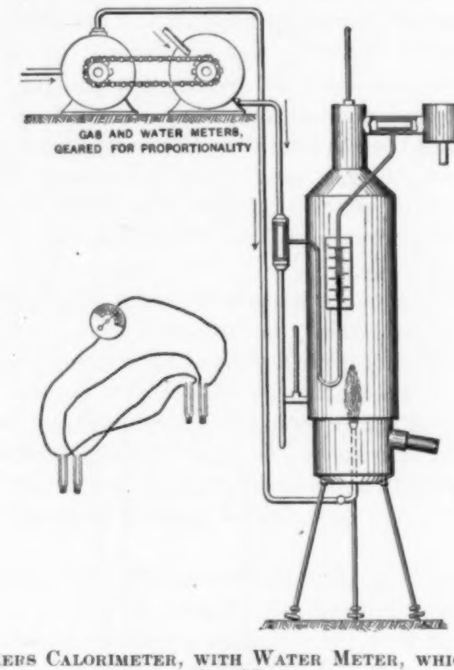

Fig. 2 Junkers Calorimeter, with Water Meter, which is Geared to Gas Meter

by a sliding scale extending over the stems of the two thermometers and graduated the same as these thermometers; the zero to be applied to the low temperature and the rise to be read off directly opposite the high temperature. By introducing on this sliding scale the constant of proportionality fixed by the meters, a second scale may be added, giving the British thermal units per cubic foot of gas directly.

16 To make the instrument recording, or to permit it to be read from a distance, Junkers proposed a thermo-couple and a milli-volt-

meter, which may be either indicating or recording in type, and it will give directly the temperature difference between the hot and cold junctions.

17 A second means of attaining proportionality was proposed by Schutte and Koerting and a patent granted to them covering it on January 2, 1906. This involves the principle of displacing gas by the water to be used, both directly and indirectly, two forms being shown. In the direct form, Fig. 3, a pair of small tanks is arranged above the gas heater or calorimeter and provided with numerous valves and ports to control the flow of water and gas. Water admitted to one of these chambers displaces gas from it, the gas having previously been drawn in while the water was running out to the instrument. The various valves are operated by the rise and fall of these two chambers, due to the weight of water they contain, with the net result that the water and the gas are taken alternately from the right and left hand chambers, the gas being forced to the burner by the filling of one chamber with water, and the water being supplied to the instrument by the emptying of the other chamber simultaneously, drawing in a gas supply.

18 This principle of displacement produces intermittent action and an element of uncertainty in momentary ratios of water to gas, because the rate of gas supply depends on the rate with which a tank fills with water from a constant head supply, while the rate of water supply depends on the rate with which a similar tank discharges this water under a variable head. In order that the momentary rate of filling and emptying two similar but separate tanks may be the same, there is involved a very complicated problem in practical hydraulics which is not here solved.

19 The second form of apparatus for the attainment of proportionality proposed by these men, Fig. 4, includes a pair of piston pumps and is free from the objection noted above, but is also very complicated and costly. The principle involved in both of them however—the attainment of proportionality by displacing the gas with the water—is extremely interesting, although its practical application is somewhat difficult to reduce to simplicity and positiveness.

20 Another interesting new point in this case is the means proposed for recording the temperature differences after the proportionality is established. Instead of using the thermo-couple proposed by Junkers, a means is shown depending upon the expansion of a liquid which is really a differential liquid thermometer. Into the water

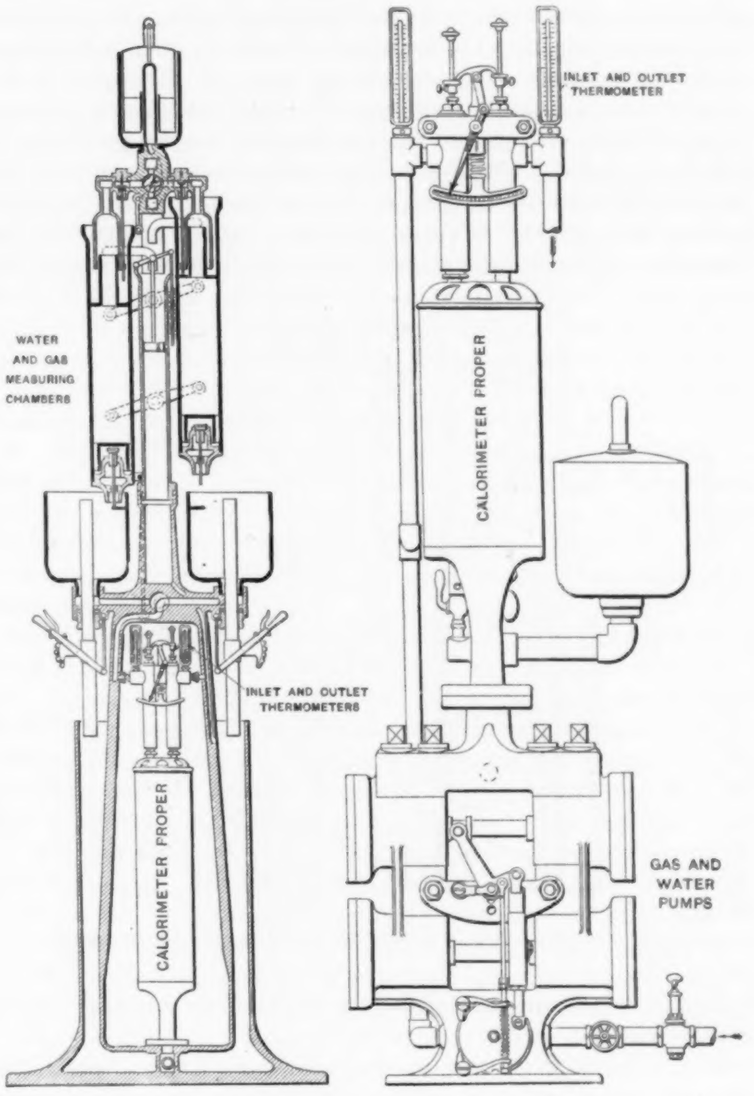

Fig. 3 Fig. 4

Two Types of Calorimeter by Schutte and Koerting, with Means for Attaining Proportionality of Water and Gas

entering the instrument and into the water leaving the instrument two small liquid chambers are inserted, each provided with a small plunger projecting out through the top. As the liquid in this plunger chamber takes the temperature of the cooling liquid, the fixed body of liquid will expand and contract and the plunger projecting into it and held by a spring in one direction will rise and fall. The difference between the position of the two plungers with an initial setting indicates the difference between the temperature of the ingoing and outgoing liquid, with a certain time lag of course, and

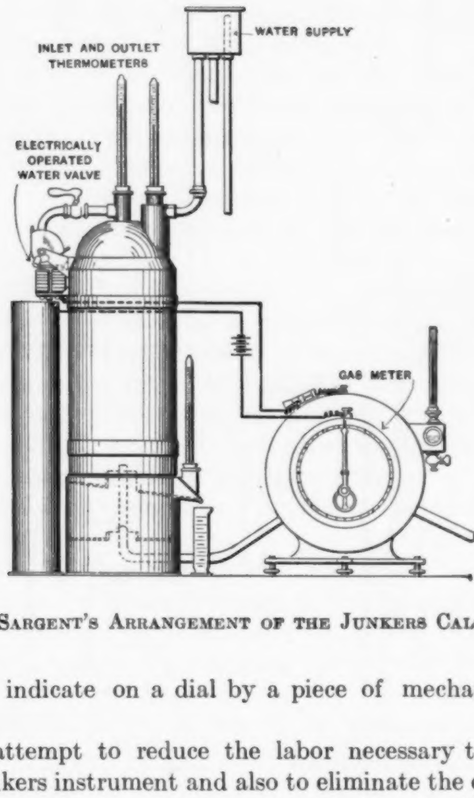

FIG. 5 SARGENT'S ARRANGEMENT OF THE JUNKERS CALORIMETER

is made to indicate on a dial by a piece of mechanism entirely mechanical.

21 One attempt to reduce the labor necessary to operate the ordinary Junkers instrument and also to eliminate the error of simultaneous reading of water and gas is shown in Fig. 5, which represents the instrument patented by C. E. Sargent March 27, 1906. The new element in this case is the water valve controlling the discharge from the heating chamber, which is magnetically operated through electrical contacts on the gas meter dial. The instrument is however

intermittent in action and requires the attention of an operator to observe the quantities and to make calculations for calorific power.

22 An instrument of the automatic sort was patented by H. L. Doherty, August 14, 1906, which in principle is much the same as that described by Schutte and Koerting. The maintenance of proportions between the water and the gas is accomplished by Mr. Doherty by displacing the gas supplied to the burner from a tank, with the water that has passed through the heating chamber. Preparatory to using the gas it is allowed to remain in the tank long enough to acquire the temperature of the room and the final temperature of the gas is adjusted by varying the effective heating surface of the heater, thus reducing any error due to inequality of the temperature of the gas, air and fuel. The instrument is complicated, requiring some sixty figures in the patent specifications to illustrate it.

23 The various attempts to render the instrument automatic and continuous have, in the first instance, involved greater complication than the original instrument, whereas it is extremely desirable that less complication be introduced and real continuity of action, instantaneous equality of rates of gas and water flow and maximum simplicity be attained.

24 The method which I have proposed and used for accomplishing this is shown in Fig. 6 as applied to the heating chamber of the ordinary Junkers instrument. It is well known that a nozzle or fixed orifice, when supplied either by gas or water under a constant pressure, becomes a very accurate measure of the quantity flowing. In this instrument shown, water is allowed to flow to the heating chamber from a water nozzle, and gas to the Bunsen burner through a gas nozzle, both supplied from a constant pressure chamber. With these nozzles the constancy of ratio of the quantity of gas to quantity of water can be maintained without difficulty, the only possible sources of error being in a considerable change of pressure, which is improbable, or in a clogging of the instrument by dirt, which probably would not be serious by reason of the mode of introducing the gas by water aspiration and the ease with which nozzles can be removed.

25 At the top is shown a water aspirator which draws gas from the main through a water seal to remove the main pressure, discharging water and gas together into the chamber. The surplus water passes down the center through an overflow and the surplus gas goes through a water sealed by-pass shown here as a glass bottle. Gas is then taken from the top of the chamber to the Bunsen burner and water from the bottom of the chamber to the water orifice. The

water supply pipe to the heating chamber is arranged to bring the inlet water thermometer close to the outlet water thermometer and in the final form of such an instrument these two stems will be arranged so as almost to touch, permitting the use of a sliding scale such as proposed by Junkers. There may also be used in place of these thermometers, and if desired in addition to them, a group of

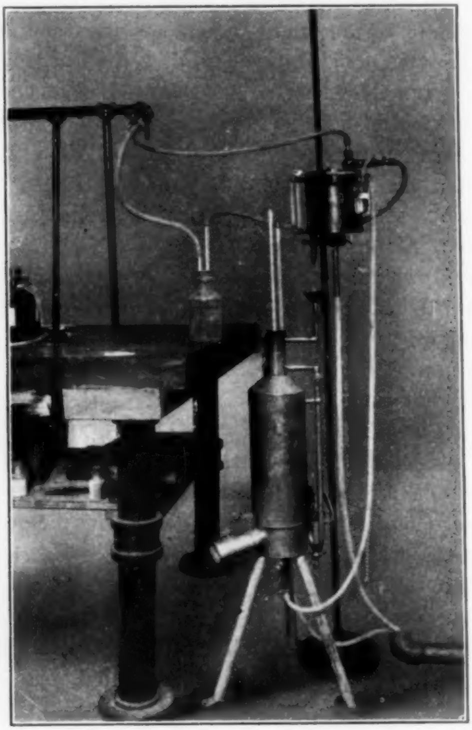

Fig. 6 Junkers Calorimeter, arranged by the Author for Giving a Continuous Record of the Quality of Gas

thermo-couples. At my request Prof. Wm. H. Bristol applied such a group of couples to this instrument in my laboratory at Columbia and recorded the temperature difference on one of his transparent smoke chart recording milli-voltmeters, which gives, so far as I know, the first continuous record made in this country of the quality of gas applied to a main for a considerable period of time.

26 It is evident, also, that the form of the chamber from which the water and gas are both supplied to the nozzle and the means for maintaining a constant pressure therein may be subject to quite a large number of variations in form to adapt it to the particular conditions or the taste of a designer, the requirements being simply that water and gas shall be supplied from a constant pressure chamber, and preferably supplied to that chamber, though not necessarily by a water aspirator, which would render both the gas and chamber pressure independent of pressure fluctuations of the gas mains. To adapt the instrument to different gases, it is only necessary to supply calibrated nozzles of different capacity. Thus, for rich natural gas a small gas nozzle and a large water nozzle would be used, while for producer gas or blast furnace gas a large gas and a small water nozzle. By the adjustment of nozzles any desired rise in temperature with any kind of gas can be secured and it takes only a minute or two to change the nozzles. Two chambers can be used if desired, one for water supply and the other for gas. This is especially desirable, even if not absolutely necessary, for gases containing matter that might be absorbed by water or lost by condensation, such as CO_2 or some hydrocarbons.

27 It is hoped that this presentation of the problem of continuous gas calorimetry, and one simple mode of solving that problem, will prove of some benefit to the gas power industry by removing one of the many uncertainties involving both the commercial and scientific phases of the question.

DISCUSSION

GAS ENGINE AND PRODUCER GUARANTEES

By Prof. Charles E. Lucke, Published in this Issue

Mr. J. R. Bibbins It would seem that the analysis of this paper by Professor Lucke had laid bare all of the troublesome uncertainties which the gas engineer is obliged to meet in the present state of the art. But although the chaotic conditions reviewed by Professor Lucke do undoubtedly exist, I believe they are more the result of inexperience or the improper application of the standards favored by the most experienced manufacturers of this country, whose specifications will generally be found to cover accurately the great majority of points raised by Professor Lucke, and to provide the customer with a specific standard upon which to base his acceptance.

2 There is, however, one uncertainty to which all of us are subject; I refer to the absolute calorific values of constituents occurring in various power gases, either in the form of pure hydrogen, or as numerous other members of the hydro-carbon family. But even on this subject it seems that authorities materially disagree, hence, the engineer may at least find partial excuse for his confusion.

3 At the very beginning of any consideration of this subject of gas engine efficiency, we are, in addition, face to face with the question of higher or "total" versus lower or "effective" heat value. To be sure, the standard gas engine testing code recommended by the Society, describes definitely the total heat value, but is it not possible that developments in this branch of technical science since the formulation of this code may make it desirable to reconsider the subject? The most important builders of this country are unanimous in their adoption of the effective heat value. It seems unfortunate therefore that the Society's recommendations and present engineering practice cannot be brought into more complete harmony.

4 A very effective statement of the merits of the case occurs in the discussion of the Society's proposed code by Mr. Arthur J. Frith, at the time of its adoption. The burden of his remarks was an attempt to discriminate between condensible and non-condensible

vapor engines, which is entirely proper. The internal combustion engine belongs to the latter class, and as such should be credited with the latent energy of any moisture carried through the cycle in the form of superheated steam. But from what limiting temperature or datum should this heat carried through the exhaust be deducted—from 212, 62, 32 deg. or from the temperature of the atmosphere prevailing at the time of the test? The latter I understand is the basis employed by German engineers.

5 Without having studied the matter conclusively, it seems to me that the entropy diagram would be of material assistance in formulating ideas along the lines discussed; i. e., to locate the proper datum from which to compute effective heat values. While the exact entropy changes above 212 deg. are open to some uncertainty, owing to the fact that the gas and vapor cycles are not in phase, so to speak, the sub-atmospheric areas are entirely definite and readily indicate the relative values of these various bases of computation. I therefore suggest that some consideration be given this entropy study in the future work of standardization.

6 It will be apparent that with the disparity in practice above outlined, it is well nigh hopeless to compare gas engine efficiencies unless brought to a common basis, viz: effective heat values. In fact, I do not see how there can be any question on this point, as the following example will indicate: First, the case of blast furnace gas: With a leaky tuyere at the furnace, the water is immediately dissociated, resulting in a bad "dose" of hydrogen at the engine. Are we justified in inferring that the gas engine, as a thermal agent, shows impaired efficiency because of the greater amount of latent energy in vapor formed by combustion within the cylinder? Second, a suction producer in which the moisture developed by the evaporator varies abnormally for reasons quite external to the gas process: Do the resulting fluctuations in the hydrogen content of the gas, and consequently the latent heat of the vapor formed, result in corresponding fluctuations in efficiency of the engine? Third, the case of a heating gas. Some producer builders argue for a high hydrogen gas for heating purposes. This, of course, is on account of the higher flame temperatures desired, but it would appear that the furnace is on the same plane as the gas engine as regards ability to utilize the latent heat of vapor formed during combustion, for these products of combustion are discharged at even higher temperatures.

7 In view of the above, it is evident under what a considerable disadvantage the builder labors who adheres to effective heat value

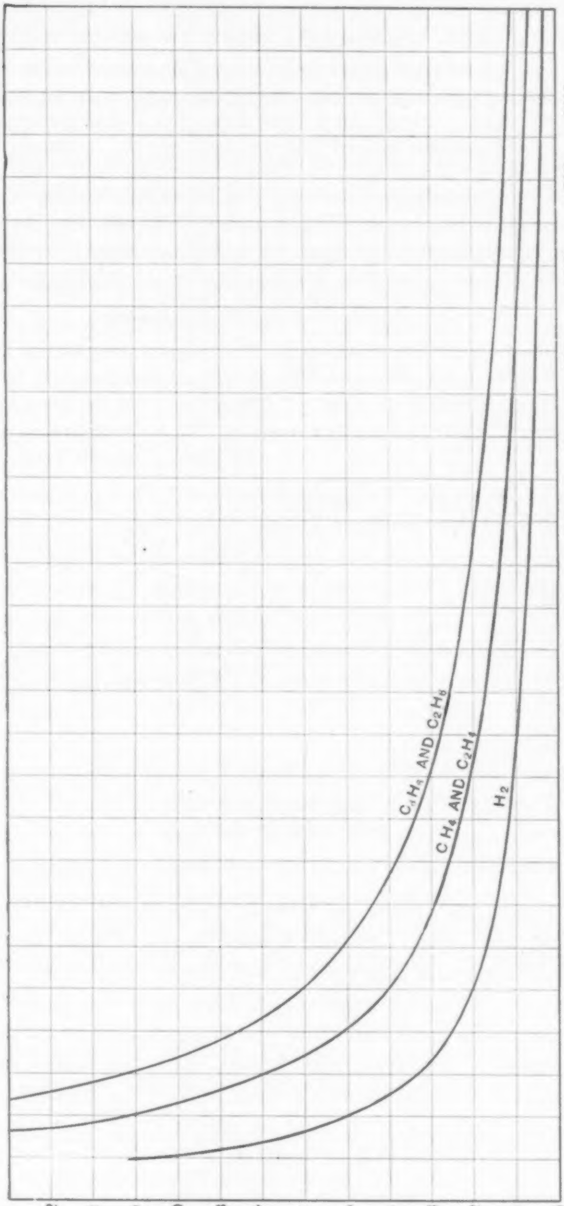

FIG. 1 RELATION BETWEEN HEAT VALUE OF GAS AND LOSS DUE TO THE HYDROGEN CONTENT

as a proper basis for computing producer efficiencies, as compared to one who uses the higher heat value. And if a customer should purchase engine and producers separately, one guaranteed on lower and the other on higher heat value, there exists a wide gap which often requires more than tact for amicable adjustment. With these conditions prevailing, I believe one of the first duties of this gas power section should be to bring this matter to a satisfactory basis.

8 The accompanying curves, Fig. 1 and 2, indicate how important is this difference between higher and lower heat value for different gases tested by the Junkers calorimeter. The ordinates are ex-

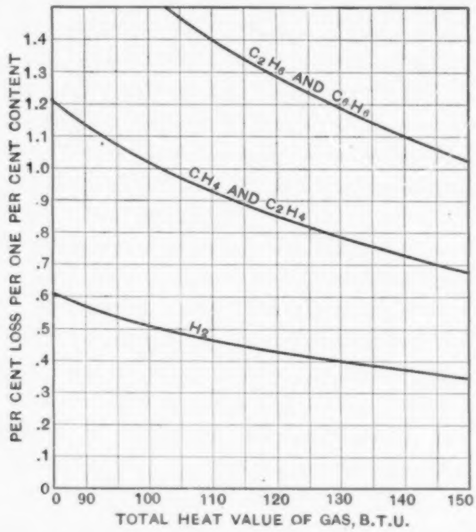

Fig. 2 Diagram of a Part of Fig. 1 on a Large Scale

pressed in per cent loss per 1 per cent of constituent, as shown by volumetric analysis. Fig. 1 covers a wide range of heat value and Fig. 2 a limited range to a larger scale, corresponding to blast furnace and producer gas. Thus for a gas of 130 total heat units showing 20 per cent hydrogen, the loss from hydrogen vapor would be 8 per cent, giving an effective heat value of 119.5 B.t.u. For other hydro-carbons the loss is directly as the atomic proportion of hydrogen. These curves are based upon the total heat of steam at 32 deg., using the most recent values for the atomic weights.

Mr. F. E. Junge[1] Referring to the designation of heating values in guarantees, the "Rules and Regulations for Testing Gas Producers

[1] Consulting Engineer, New York.

and Engines," as prepared by the *Verein deutscher Ingenieure*, Berlin, Germany, contain the following passage:

The calorific value of a fuel is to be taken as its lower heating value, that is, the heat which is liberated through the complete combustion of the fuel when the burned products are cooled down to the original (room) temperature at constant pressure, it being assumed that the combustion water and the moisture contained in the fuel remain vaporized. The heat value of gaseous fuels is based on 1 cu. m. at 0 deg. cent., and 760 mm. barometer pressure, or it is expressed in calories as "effective" heat value, that is, reduced to 1 cu. m. of actual gas available. If nothing special is mentioned, then it is always understood that the heat value recorded has been reduced to 0 deg. cent. and 760 mm. barometer pressure. The efficiency of a gas producer plant is the ratio of the heat contained in the gas as produced to the heat of combustion of the total weight of fuel consumed in the plant, both items being computed from the lower heating value. In producer gas plants having a separately fired steam boiler, it is advisable also to determine the ratio of the heat which is chemically bound in the producer gas to the heat equivalent of that portion of the fuel which is consumed in the producer proper for making such gas.

2 Referring to the unavailability of information on compression pressures in internal combustion engines, authors are quite justified in evading general tabulated statements of compression pressures attainable with various gases or fuel vapors, because these pressures depend greatly on the size of the engine, the form of the combustion chamber, and the influence of jacket cooling, which factors are yet entirely dependent on local conditions of design, construction and operation.

Mr. E. Rathbun It may be interesting to some of the members to know of a recent installation in New York of gas engines for refrigeration, aggregating about four hundred horse power. The installation is at the plant of Swift & Co., on 152d street. Their disposition is to open it for inspection at any time. It is a duplicate plant, four 100 h.p. units on producer gas; two being direct connected to generators, and two chain connected to ammonia compressors.

Mr. Henri G. Chatain It may be of interest to give a brief and general description of the gasolene-electric car we have developed in our Schenectady works.

2 The car is intended for use on small branch lines for railway service, a subject that has been agitated for several years and very strongly for the last few years. The car, some fifty feet in length, has a seating capacity of 46 persons and is driven by a gasolene

engine. It is an eight-cylinder engine, of the V type, the cylinder set at 90 deg., such as an eminent French engineer has developed for flying machine motors. This type of engine was selected as this class of work requires a compact and light engine, and we found that by using eight cylinders, we secured an engine which satisfactorily met these requirements.

3 The engine has cylinders eight inches in diameter by seven inches stroke and develops 125 h.p. continuously at 550 revolutions. It is direct connected to a special generator and develops a brake horse power from something less than a pint of gasolene per hour. The valves are on the same side of the engine and are operated from a cam shaft situated directly in the V part of the engine, one shaft operating both valves. The ignition is by high tension spark coil and battery. The carburetters are of the Venturi type, without any auxiliary air valves whatsoever. We find, for an engine of this size, that satisfactory results at all loadings and all speeds can be obtained by properly proportioning the Venturi tube without auxiliary air valves for the admission of air to compensate for the varying velocities past the nozzle. The carburetter is fed by means of the customary float feed.

4 The cooling of the engine is effected by thermo-siphon circulation. About thirteen hundred square feet of radiating surface are required, which necessitates about one thousand pounds of copper and brass tubing.

5 For starting the engine we have adopted a scheme for "shooting" it. One cylinder is equipped with a breech block which takes a ten-bore shell loaded with approximately 300 grains of fine grain black powder. The engine is barred around so it is slightly over the center for this cylinder. The ignition system is turned on, and the cylinders are all primed. When everything is in readiness the cartridge is shot by means of a simple trigger arrangement. We found this to be a satisfactory method of starting the engine. The products of combustion from the black powder are not at all injurious to the engine. After long runs we have taken the cylinder down, and no deposits of any amount were noted; in fact, the products of the powder mix with the oil and do no injury. The arrangement makes a very cheap and easy method of starting.

6 The engine weighs complete a trifle less than thirty-nine hundred pounds. This, I think, covers in general the size, weight and horse power of the engine, but it may be of interest to say a few words in regard to the other members of the car.

7 The system of drive is electric, the engine being direct connected to a generator separately excited, the exciter also being direct connected to the main shaft. The car is controlled by varying the potential of the generator, which gives the necessary flexibility in regard to torque and speed. The engine is capable of a certain kilowatt output, and this kilowatt output may be utilized in the two motors under the car, which can be used both in series and in parallel, and this output is capable of being used in any form that the road conditions demand. In other words, the volts and amperes are interchangeable through the separately excited machine. A large current is taken to start the car, and the current gradually falls off and the potential gradually rises until the car has attained full speed.

8 The rate of acceleration of these cars is somewhere between the ordinary inter-urban electric car, and the steam locomotive; not quite as good as the electric, and a little better than the steam. A 125 h.p. engine, such as we have, is capable of running this car, which weighs approximately 31½ tons, at a maximum speed of a trifle over fifty-five miles an hour. This speed, in contra-distinction to steam equipment, can be sustained indefinitely. We could load up with gasolene and run as long as the gasolene lasted, at exactly the same speed.

9 As to the gasolene consumption, the car is capable of making approximately 2.5 miles to the gallon of gasolene, which, at the rate the railways pay for gasolene, is rather a small fuel charge.

10 I might say that the ordinarily accepted idea of the gasolene engine, due, possibly, to its early development in the automobile, that it is not a reliable source of power, is not correct; I can say emphatically that the gasolene engine will develop power sufficient to propel a car in constant service all day long and do it as reliably as a steam engine.

11 This covers the main features of this outfit, but before closing I would like to suggest that some one give us a talk on compression. That is a subject, it seems to me, that is very much neglected.

A SIMPLE CONTINUOUS GAS CALORIMETER

By Prof. Charles E. Lucke, Published in this Issue

Mr. Henry L. Doherty I am the inventor of the calorimeter which Professor Lucke described as very complicated, and if I am not mistaken, I am the earliest inventor of the displacement principle in this connection. When my application went into the patent office, no citations were given me of antedating patents.

2 The question of a continuous gas calorimeter is, I think, of considerable importance, especially for producer gas. The calorific value of a gas changes very quickly, and a continuous gas calorimeter that will not lag too far behind the operation of the producer is important, and one of the greatest considerations is to get a prompt record of the performance of the producer, and not have the calorimeter lag behind several minutes, as is apt to be the case. We have gotten very good results by simply burning gas in an open flue, and recording the temperature of the escaping flue products. This is a scheme which is positive and will give accurate results, but I have not applied for patents on this calorimeter, and have never put it on the market; nor have I ever put the other one on the market, which Professor Lucke termed complicated, and which, by the way, a green operator can run continuously within four British thermal units on a gas of 600 B.t.u., and come within half of 1 per cent.

3 In treating so called gas turbines no distinction was made between what I would term the true gas turbine and the steam turbine, with a little of the products of combustion mixed in, as is the case where gas is burned and its temperature dissipated by vaporizing water. I believe that a great deal of good work that might have been better applied, has been put on the development of the true gas turbine, for I do not think we have material that will stand both the velocity required and the high temperatures of combustion of a gas. I think a distinction should be made in our literature and nomenclature regarding a gas turbine and one which works with steam.

THE RATIONAL UTILIZATION OF LOW GRADE FUELS IN GAS PRODUCERS

By F. E. Junge, Published in Mid-October Proceedings

Mr. R. E. Mathot The very elaborate paper of Mr. Junge deals almost entirely with theoretical suggestions and general considerations regarding the efficiency of gas motive power. Perhaps it may not be out of place to describe here a little practical device, the use of which may lead to economy in the operation of gas plants by securing a method of watching the nature of combustion in the gas engine's cylinder.

2 If combustion is complete, owing to perfect mixture, which affords high efficiency, the exhaust gases should not contain any unburned gas such as CO. The presence of this gas in very small proportions in the exhaust can be detected by a simple appliance.

A small glass flask, about two inches in diameter and four inches high, closed with a cork, through which pass two vertical tubes, is used for collecting some of the exhaust gas. One of the tubes is connected to the exhaust pipe of the engine, while the end is plunged in mercury about one inch deep in the flask. As soon as the connection between the exhaust pipe and the flask is established, some exhaust gas will be blown into the flask at each stroke, and the mercury, operating as a check-valve, will prevent it from being withdrawn. The air contained in the flask, and afterward the exhaust gas, will be expelled through the second pipe open to atmosphere and ending inside, at the top of the flask.

3 To detect CO, which is contained in the exhaust gas continuously rushing through the flask, a small piece of white blotting paper is hung in the flask, the paper being previously prepared by dipping five or six times in a solution of double chlorid of palladium and sodium of such concentration as to give a dark brown color, and drying after each immersion.

4 If there is more than 1 per cent of CO in the exhaust gases, the paper will, in two or three minutes, lose its bright brown color and become gray. This shows insufficient air in the mixture for combustion, which can be corrected at the mixing valve.

Dr. J. A. Holmes In discussing this admirable and interesting paper, it is perhaps appropriate, in view of my own work, that I should allude to points connected directly with the investigation undertaken by the Government at the St. Louis Exposition, and which have been more or less continued, in part, under the supervision of the representatives of this Society. I desire particularly to call your attention to that phase of the investigation dealing with wastes that have taken place in mining, and in the utilization of both high grade and low grade fuels.

2 The investigations that have been conducted at St. Louis, at Norfolk, and at Denver, during the past three years, had for their cardinal purpose the comparison of one character of fuel with another. It was hoped, and in part only was that hope realized, that these engineering investigations would give us results even more valuable than they were; but the equipment which we were compelled to use in the beginning was selected because it represented the ordinary power plant in use in the United States, and the comparisons of the various fuels have been made on this equipment with only such slight modifications as were feasible at the time. It has been common

to find, where there is a vein eight feet in thickness, that two or three feet is left unmined, permanently lost because of the subsequent caving-in of the mine. We have found, furthermore that, as Mr. Junge says, there is no sharp line between high grade and low grade fuels; that in certain mines the amount of coal left unmined, under the ground, exceeded 75 per cent of the total available coal, and the average result is that at least 50 per cent of the possible coal supply in these veins is left under the ground and unrecoverable.

3 This 50 per cent of the total possible coal product referred to as being left underground includes, besides the supporting pillars, also the low grade parts of the coal beds and the adjacent overlying beds of coal damaged in mining the lower beds. This, like the loss of the 95 per cent of the heat units in converting coal into work, will probably never be entirely preventable, but every decided advance along either of these lines is a distinct gain and contributes both to the present and the future welfare of the nation.

4 Now we have found that the percentages vary all the way from 20 to 70 per cent ash in the so-called low grade coals. I recall one case in particular in which out of a possible 25 ft. vein of coal only four feet were taken out because of unskilfulness in mining, and the rest left underground and practically destroyed. The carelessness with which coal miners have gone to work mining the lower seams and allowing cave-ins to follow, has had the result of leaving the coal in the higher seams unmined and practically lost because of the caving-in of the adjacent material. In West Virginia, and in Ohio, and in various other places, the cost of mining has been greatly increased, entirely out of proportion to the amount of coal that has been mined, because of this carelessness.

5 I desire to call attention to the possibility of utilizing these coals by the location of plants at the mines, thus avoiding the cost of transportation. Consider as a single illustration the Pennsylvania Railroad, which uses 40 000 tons of coal every day in its own locomotives. If, as is now being attempted, all of that power can be generated from low grade fuels now not utilized at all, we shall see an enormous gain in the direction of a solution of our fuel problems and our problem of transportation would be vastly lessened. Consider for a moment what the application of this same thought would mean to the 100 000-000 tons of coal now annually consumed in our locomotives.

6 Very few persons realize that so rapidly is the fuel industry developing that during each succeeding decade for the past 85 years the amount of coal mined and used in the United States

has equaled that of all the preceding decades; so that the amount of coal mined and used between 1895 and 1905 was equal to that mined and used during the preceding 75 years. Now, there has not been a corresponding increase in efficiency, nor has there been any marked gain in the utilization of the low grade materials. Hence, what we are doing at the present time is skimming the surface, using the high grade coals and leaving the low grade coals, using the surface coals and leaving the deeper coals. Therefore, we are approaching a condition where our coal cost will be greatly increased and the amount of available high grade coal very much diminished. I am not now prepared to say when that time will come, but we trust that our coal supply will last as long as that of any other country; still we must awaken to the fact that our high grade coals are passing so rapidly that coal lands used for supplying coke and for other special purposes in Maryland and in West Virginia cannot be purchased in many sections for less than $1500 to $2000 an acre.

7 In the extreme westerly portion of our country we find, too, a spirit of wastefulness which has doubtless been developed from the luxurious wealth of the country until one can hardly realize the extent of it. Recently we had occasion to investigate the lead and zinc products of the country, and we found that fully 50 per cent of the possible supply is left unmined underground or wasted in processes of treatment. The same thing applies equally well and just as truly to other mineral resources of the country.

8 I may say, in conclusion, that while these investigations have been in part under the supervision of this and the allied engineering societies, the President of the United States has, in his message to Congress, recommended the establishment by the Government of a special bureau for mining and engineering investigation, in which the work initiated at St. Louis in a crude way may be placed upon the highest possible plane as to equipment and engineering data. It is proposed, furthermore, that this new bureau shall be an independent bureau under the Department of the Interior and working in coöperation with the Geological Survey, and shall be placed entirely under the supervision of the representatives of national engineering societies and other allied bodies, who, together with those chiefs of Government bureaus who have to do with actual construction work, shall direct the energies of the department.

Mr. R. E. Mathot I have been interested in the competition between the gas and steam engine, but I do not agree with those

who affirm that the gas plant will drive the steam engine from the field. On the contrary, I am of the opinion that both kinds of motive power will grow side by side and even stimulate each other to greater improvements.

2 In a series of articles contributed to the Engineering Magazine at the beginning of this year, I described several installations of steam and gas plants to meet different conditions. Gas, steam, liquid fuel or water, as sources of motive power, each possesses qualities better adapted to some special purpose than the others.

3 The low figure attainable in a suction gas plant of 0.7 lb. of anthracite per brake horse power hour, has been met by the correspondingly low figure of 1.35 lb. of bituminous coal in a steam plant. Such steam plants are not, of course, common and the figure given refers to a type of semi-portable engine, made by two well known German firms, H. Lanz in Manheim and R. Wolf in Magdebourg, with a self-contained boiler, the engine being mounted upon the boiler which supports its chimney stack.

4 The boiler is of the horizontal type with internal corrugated furnace from which extends a set of fire-tubes. The furnace and tubes are a removable system. The single or double superheater is placed immediately behind these tubes, in the fire-box, so that superheating is obtained by the heat of the gases before passing to the chimney. The engines are horizontal, of the piston-valve slide type, and are made single, compound or triple expansion with single, double or triple superheating ranging from 300 deg. to 350 deg. cent.

5 The very low consumption is mainly due to the high efficiency of the boiler and superheating arrangement, although the heating surface is small; to the high working pressure; to the absence of steam pipes; the high speed of the engines and high grade workmanship.

6 The following figures are abstracts of a test that has been recently made on one of these semi-portable engines.

Brake horse power	150
Mechanical efficiency	92 per cent
Initial steam pressure	180 lb. sq. in.
Steam vaporized per pound coal	8.5
Gross consumption bituminous coal per brake horse power hour	1.22 lb.
Heat values of said coal	14 500 B. t. u.
Ash	6.2 per cent.

7 Another test on a 300 h. p. engine has shown even better results. Full data of the experiments and the illustration of these engines have been published in Power.

8 It is proposed by Mr. Wolf to do still better and he is building a 500 h. p. triple expansion, semi-portable engine, with triple superheating; that is, the steam is separately superheated before entering each cylinder. He expects the following results:

Working horse power	500
Initial steam pressure	215 lb.
Heating surface	815 sq. ft.
Gross coal consumption per brake horse power hour	0.99 lb.
Steam per brake horse power hour	8.15 lb.

Mr. H. H. Suplee In regard to the performance of the Wolf engine, of which Mr. Mathot spoke, I think there is no doubt about its very high efficiency. I had occasion some time ago to examine some data and results of tests on some of these engines made by Professor Gutermuth, and the performance corresponded very closely to the figures given by Mr. Mathot.

2 The high efficiency in this case, I think, is largely due to the elimination of transmission losses. It was shown at the Chattanooga meeting, and also by the experiments of Dr. Berner in Germany, that superheated steam loses its heat very rapidly. In the Wolf engine, the steam passes first through a coil superheater in the smoke box, where the greatest amount of heat is received, and from thence the steam passes directly to the high pressure cylinder. Then there is a similar reheater between the high and low pressure cylinders, and again a very short connection, and the engine is practically working with steam which corresponds very closely to what Professor Rankine calls "steam gas." Mr. Mathot speaks of steam temperatures corresponding to 300 deg. cent., or 572 deg. fahr., and at such temperatures the steam is so far removed from the saturation point as to be practically a gas.

3 Such engines really hold a sort of intermediate place between the steam engine and the gas engine, and should be so considered, and their performance bears out this classification.

4 I think that the results of Mr. Mathot with the Wolf engine are fully confirmatory of those obtained by Professor Gutermuth.

Mr. J. R. Bibbins This subject presents a number of extremely interesting phases, not only in steam, but in gas power application. I wish to refer particularly to the low grade fuel produced in enormous quantities at the various anthracite collieries that appears to be largely unmarketable.

2 Low grade bituminous coal, such as the poorer lignites and and mine refuse, presents a problem quite distinct from that of anthracite refuse. The Jahns producer has been mentioned in this connection, from which excellent results have been obtained in Germany, some of the coals running as high as 70 per cent non-combustible. This, on its face, would almost indicate a solution of the bituminous producer problem, but we learn that all fuels possessing the obnoxious coking qualities (such as tend to form a solid mass in the producer and impede the progress of the blast gases) are unfit for use in this producer. This disqualification puts the damper on our enthusiasm for bituminous producer work, which the average European finds it difficult to understand in regard to American practice. The relative

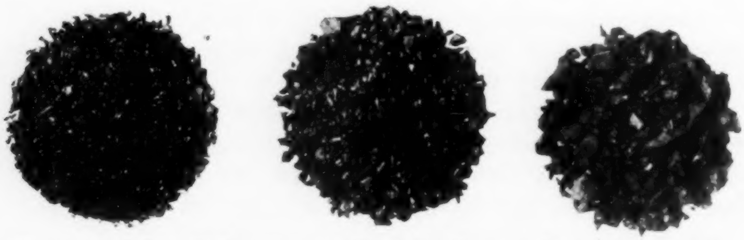

FIG. 1 SAMPLES OF BUCKWHEAT, RICE AND BARLEY; RICE AND BARLEY; AND CULM, RESPECTIVELY

character of coals appears to be the point at issue rather than the type of producer, and in the last analysis the most successful producer will be that adapted to the use of the cheapest form of bituminous coal, such as Pittsburg or Illinois slack.

3 With this digression, we return to the subject of anthracite, and it may be of interest to the Society to know of some results that have been obtained in a practical producer test[1] having for its object the determination of the operating qualities surrounding the use of these fuels. It may have some bearing upon the subject to say that our attitude was consistently negative, and the tests were made purely in the interest of a large coal operator who desired to market his low grade product in the form of electricity conveyed by long-distance transmission to centers of consumption, rather than in the form of small sized coal for which the market is neither stable nor lucrative. Part of the product, culm, cannot be marketed at all, and it is constantly accumulating at an embarrassing rate.

[1] Made in the producer gas testing department of the Westinghouse Machine Company, East Pittsburg, Pa.

4 The samples available for test are shown in Fig. 1 and comprise mixtures of No. 1, 2 and 3 buckwheat in the proportions regularly delivered by the breaker, it being the idea to expend no effort whatever in attempting accurate sizing. At this breaker, No. 1 buckwheat passes *through* a nine-sixteenths inch screen, and No. 3 or barley *over* a three-thirty-seconds inch screen, the remainder being culm. Of these sizes, two series were tested; the first, freshly mined coal, and the second, crushed coal from the surface of an old "slate" pile containing 200 000 tons that had weathered for 20 years, but with apparently very little deterioration. The latter contained some "bone," but little slate, and on the present market would probably pass as a fair grade of coal. Practically the same results were obtained from both series of samples. The smaller sizes analyzed as follows:

PROXIMATE ANALYSES

	Rice and barley. Per cent	Culm. Per cent
Moisture	8.2	3.43
Volatile matter	5.73	4.87
Fixed carbon	62.72	61.07
Ash	23.35	30.63
	100.00	100.00
British thermal units per pound	10 918	6748
Through one-sixteenth inch screen, per cent	9.16	84.0
Sulphur		2.34

5 These mixtures were tested in a 500 h.p. standard pressure producer, operated in connection with the gas engine testing plant. No alterations were made in the plant to accommodate the smaller size fuel, and the same producer men were employed, although none of them had had previous experience with small low grade fuel.

6 The tests extended over a period of several weeks' duration. As buckwheat was standard producer fuel, and had already been used successfully in large quantities, no attempt was made to screen out this size. The buckwheat mixture, therefore, proved quite satisfactory. No bad clinker developed, and, with ordinary care, the fuel bed could be kept in good condition and normal gas generated.

7 It was, however, found desirable to reduce the usual depth of fuel bed about 25 per cent, to lower the resistance to the blast, but, other than a slightly higher blast pressure, results were not appreci-

ably different from those obtained with the coarser fuel. The producer was handled carefully, but no more so than in the case of normal operation.

8 The accompanying log, Fig. 2, shows the results obtained upon the eighth day of this continuous run on rice and barley. Note that this log covers a continuous period of seven hours, and that the uniformity of the results obtained is the best indication of their accuracy. Short time tests are always open to criticism by reason of the fact

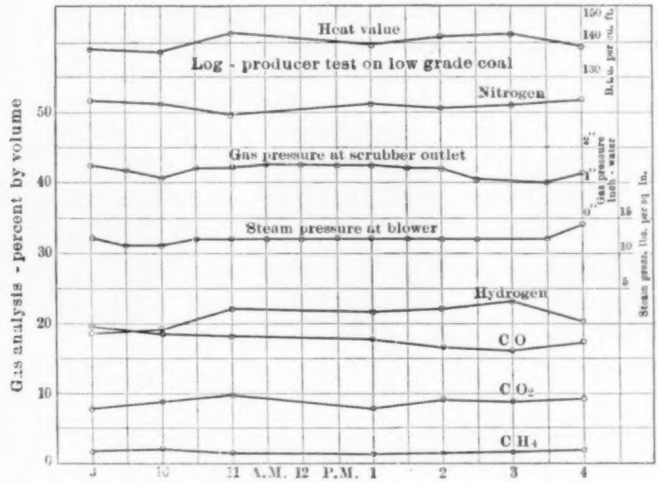

Fig. 2 Log of Producer Test, Low Grade Anthracite

that the results are so much more subject to internal influences, especially variations in the methods of charging coal. Note that the *total* heat value only is shown on this log.

9 A day's trial, with a mixture of culm, rice and barley, soon indicates the inadvisability of using straight culm, which was practically dust and showed a natural tendency to pack the fuel bed more than ordinary blast pressures could overcome, and as it was apparent that successful operation for any length of time would be problematical, involving more care than the low market value of the fuel would warrant, this fuel was abandoned.

10 During the succeeding days of the test, the producer was run on a rice and barley mixture, by some new men who were furnished with no special instructions as to the method of handling the producer. Naturally the results were not as good, Nevertheless, the full engine

load was maintained as usual. The following table gives a fair example of the gas made by these "green" operators, as compared with that possible with careful operation, as shown by the log.

GAS ANALYSES

	Fair gas Per cent	Good gas Per cent
Carbon dioxid	9.4	9.6
Carbon monoxid	14.6	17.8
Methane	1.2	1.2
Hydrogen	16.9	21.9
Nitrogen	57.9	49.5
Total British thermal units per cubic foot	115.5	142.5
Effective British thermal units per cubic foot	105.0	127.0

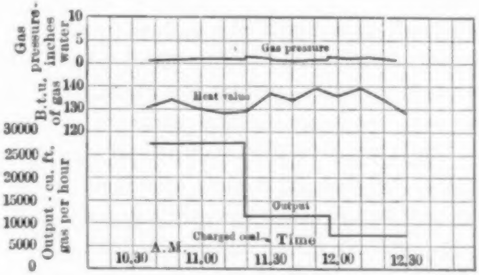

FIG. 3 LOG OF THE TEST OF AUTOMATIC PRESSURE REGULATOR OPERATING ON 500 H. P. PRODUCER

11 A large variation in producer output with this fuel need have no effect upon the heat value of the gas, providing the blast is controlled automatically. The accompanying log, Fig. 3, shows the results obtained during two hours of a run with this point in view. During this period coal was charged only once; the heat value averaged 131 B.t.u. total per cubic foot, varying only 3.75 per cent from the mean. With the instantaneous changes in output shown by the lower curve and the practical uniformity of the gas, the point is clearly proved.

CONCLUSIONS

12 With careful operation, a buckwheat, rice and barley mixture will produce a gas quite equal in heat value and uniformity to standard gas made from pea anthracite. With the rice and barley mix-

ture alone, a gas as low as 100 B.t.u. may be expected at times, and should be provided for in the design of the gas power equipment. Gas engne ratings should manifestly be based upon such cylinder sizes as will be sufficient to insure full load with the poorest gas allowable. Undoubtedly present standard producer and engine ratings might be adhered to with careful and intelligent operation. This is quite true with the buckwheat mixture, but with finer mixtures conservative engineering dictates slightly lower ratings, especially in mining regions where low priced labor must be reckoned with. This departure from present standards, however, is a matter for individual consideration and not necessarily broadly applicable.

13 Now the question arises: Whether commensurate results may be obtained from this low grade anthracite burned under steam boilers, and if so, will the gas engine proposition be outclassed in the financial balance sheet? My observations at the collieries where this fuel is produced leads to a negative conclusion, as far as comparative operating costs are concerned. At this plant a mixture of rice with a little barley is used on a flat herringbone grate with three-sixteenths inch openings, with a grate surface ratio of one-thirty-fifth, the average firing rate is only 13.8 lb. per square foot of grate surface per hour and with induced draft of one to two inches in the flues. One fireman cannot handle conveniently more than 450 h.p. capacity, or about one gross ton per hour. A test with rice on a 300 h.p. horizontal return tube boiler gave an evaporation of 6.23 lb. per pound of dry coal and about 75 per cent rating. This is equivalent to an average evaporation of about 5.75 lb. as actually fired.

14 In general terms, the subject seems to present the following aspects:

a Hand firing is a practical necessity, involving at least three times the labor required for producers equipped with coal handling machinery;

b Boiler efficiency decreases rapidly with sizes below one-fourth inch, probably averaging not over 50 per cent with a rice and barley mixture;

c Boiler capacity is similarly affected, affording little or no forcing capacity;

d The effect of ash in large percentages has a far more serious effect on boiler than on producer efficiency and capacity. Mr. W. L. Abbott's valuable experimental work with bituminous screenings, illustrates this in a striking man-

ner. He has shown, however, that within reasonable limits, low grade *bituminous* coal can be used successfully and stoker fired. A recent test at full boiler rating on an 800 horse power double fired boiler equipped with Roney stokers has also shown good results with buckwheat anthracite containing as much as 23 per cent ash; a firing rate of 20 lb. per square foot of grate surface per hour; a boiler efficiency of 75.6 per cent, and an equivalent evaporation of 8.77 lb. per pound of dry coal.

15 Thus a certain part of the low grade fuel fields is available for steam purposes with mechanical stoking, but it seems conservative to limit the boiler to No. 1 buckwheat size for the most effective results. Below this size the producer evidently finds a special and fortunate application.

16 Finally, a word as to sizing. Mr. Coxe (Report of Pennsylvania Coal Commission) has shown that a most confusing state of affairs exists in this regard. At the time of this investigation by the various operators there were in use 12 different specifications for pea, 15 for buckwheat, 16 for rice, 5 for barley and 16 for culm, the latter varying from a one-sixteenth inch round to a three-eighths inch square mesh. Both wire screen and punched plate were in use with square, round, oblong and slotted apertures, these varying from 30 to 100 per cent in diameter for supposedly the same size coal. Obviously, the only remedy for this muddle is a rigid standardization, and until such mutual action is taken, the customer must familiarize himself with local standards of the various collieries.

17 In regard to the trend of the preceding discussion on the general use of low grade fuels, I believe Professor Lucke's remarks are not representative of present conditions, or at least do not carry the proper inference. The relative "expensiveness" of two power propositions, involves operating, as well as fixed charges. Admittedly, the gas power equipment is at present more expensive in first cost, but in the great majority of cases (excepting only those of exceedingly low fuel cost and loading factor), it quickly makes up for the deficiency by reducing the operating costs.

18 I cannot agree with Professor Lucke that the equipment labor cost is much higher in the gas generating than in the steam generating plant, as I have pointed out above in the case of low grade anthracite. The specific instance he cites, in which the producer labor was abnormally high, does not apply, in the

least, to a well managed plant. When it is considered that in a producer plant, only one-half, if not a smaller percentage, of the total fuel tonnage of an equivalent steam plant has to be handled, and this practically by gravity, the injustice is apparent; and only in the case of a comparatively large installation, where fuel is handled entirely by good mechanical stokers, will a steam plant be able to rival its competitor in economy of labor. With high grade, double acting gas engines, in which lubrication is accomplished entirely by automatic means, where is the opportunity for the abnormal expense charged against the gas plant? Simply because some small gas installation of any given type happens to require the same number of men that would suffice for a plant perhaps twice as large, it is illogical to inveigh against the gas proposition as a whole. In the early stages of gas power development, which naturally involved small sizes of apparatus, criticism of this kind was frequent, but with the establishment of larger plants, the opportunity for normal economy in labor arose. There is, of course, considerable difference between the operation of a simple anthracite plant, involving no auxiliaries, and a bituminous plant requiring either periodical fuel bed renewal or independent purifying auxiliaries. Bituminous practice is, however, rapidly crystallizing into more simplified operation, and even at present bears out the above contention.

19 Furthermore, I maintain that an adequately designed producer can show far better results as to continuity of operation than the average boiler plant. A fundamental necessity, of course, is a water-sealed type of producer, permitting gradual and uniform disintegration of fuel to ash without necessitating the renewal of fires at week-ends. An instance will suffice, a 500 horse power producer installation at Jersey City, using small anthracite. I am informed at first hand by the engineer in chief that one of the producers, installed in 1898, was in operation 21 to 24 hours per day for a period of six years and ten months without the fires ever having been drawn. And only then was a shut down necessary because the coal feeding bell had rusted off at its point of suspension and fallen into the fuel bed from which it could not be recovered without drawing the fires. Incidentally, the producer lining was found to be practically intact, and as soon as the bell was replaced, the producer was put back into service. This clearly indicated the possibilities of the water-sealed type of producer.

20 Nor has the gas engine shown inferior results. A four months'

operating record from a Kansas cement mill shows the following results from engines of standard Westinghouse construction:

Type of engine	Number samples	Size brake horse power	Total run per cent of total time	Engine repairs, per cent of time
Four months run:				
Horizontal double acting	3	500	75.6	0.63
Two months run:				
Vertical, single acting	13	125 to 300	97.95	1.13

21 When it is considered that up to January, 1907, one manufacturer alone had equipped 69 producer plants, located in all parts of the world, varying in size up to 3000 horse power, many of them having been in operation from five to seven years, it does not seem reasonable to term the gas power system as commercially unfeasible.

Prof. C. E. Lucke It appears that I did not make myself quite clear in my previous remarks in discussing the question of labor cost in firing.

It was not my intention to give the impression that I believe a gas producer costs more to fire than a boiler when operated with favorable fuel. I do not think so at all. The point I wanted to bring out was that when we attempt to pass from favorable gas producer fuel to unfavorable then the cost of firing increases very rapidly.

DUTY TESTS ON GAS POWER PLANT

By G. I. Alden and J. R. Bibbins, Published in Mid-November Proceedings

Mr. R. E. Mathot It has often been demonstrated that the output of a steam engine apparently does not affect its friction load.

2 The most accurate method of determining the mechanical efficiency of a steam engine consists in taking the indicator diagram and calculating the power of the engine at zero load and then at normal load. The mechanical efficiency will then be expressed by the ratio of the difference between these powers to the power at normal load.

3 I have never succeeded in ascertaining exactly the mechanical efficiency in the way Mr. Bibbins reports in his paper, that is, by comparing the effective power recorded by the brake with the power calculated from the corresponding indicator card.

4 The accuracy of an indicator cannot be depended upon in recording full load on an explosive engine, for there are too many sources

of error, as pointed out by Professor Lucke, besides many mechanical troubles in the operation of the indicators. The only practical way of determining the mechanical efficiency seems to be the method used in testing steam engines.

5 A light or weak spring should be used for a series of at least 30 to 50 cards, when the engine is under no load. This operation should be repeated several times with springs of different scales, so as to check one spring by the others and they should all be calibrated for errors.

6 The indicated power so recorded would be the effective horse power required by the engine itself to overcome its own internal friction and resistance and give a means of calculating mechanical efficiency.

MR. C. L. STRAUB[1] I notice that Mr. Bibbins refers to the efficiency of the producer, based on the lower heat value of the gas. This is not a true efficiency of the producer. The efficiency of any apparatus, whether a gas producer, steam boiler, or other device, is computed in terms of the actual value of the output energy, divided by the actual value of the input energy, the result being the percentage of the efficiency.

2 The actual output value of a gas producer is represented in the higher heating value of the gas, it being no fault of the producer that the gas engine is unable to cope with the latent heat of steam, due to the combustion of hydrogen in producer gas. When reference is made to the efficiency of any gas producer, it should in justice be made to the higher heating value of the gas furnished by that producer.

3 I would also like to ask Mr. Bibbins whether, in calculating his efficiencies, he used as his fuel basis the lower heat value of the fuel, and whether the calorific value of the fuel was determined by analysis or by calorimeter. If by the former method, unless commensurate allowance was made, a high heating value was obtained. It is a fact also, that the calorific value of any fuel as determined by a bomb-calorimeter, should be referred to the lower heating value of that fuel, providing the gas produced from the fuel is also referred to the lower heating value of the gas.

4 Information was asked regarding the depreciation on gas engines and gas power plants. I know of a number of gas producer plants that have been in operation for 20 years and are still running. In one

[1] Engineer, Loomis, Pettibone Company, New York.

plant at New Haven, Conn., the average repairs per annum for seven years, have been $147. This plant was installed to burn under normal conditions, about 18 lb. of fuel per square foot of combustion area. This is at the rating of 1000 h.p. on each pair of the four units. Under their commercial conditions, they are burning considerably over forty pounds of fuel per square foot. This means that they are getting continuously over 100 per cent overload out of the producer, and their efficiencies are considerably over 80 per cent, based on the lower value of the gas.

Mr. Bibbins is to be complimented upon the very interesting paper he has presented.

Prof. William D. Ennis The thermal efficiency curve of Fig. 2 is important, and should be thoroughly established. In the accompanying diagram, Fig. 1, curve *I* is plotted from the data given in Table 1. Curve *II* represents the results of three trials made in August on a 500 h.p. Westinghouse horizontal double acting gas engine with a 300 kw. direct current generator and a gas generating unit built by R. D. Wood & Co., located at Richmond. This curve shows a less economical performance than the former, but the light load efficiency is higher in proportion to the full load efficiency. In other words, the curve is less steep. The results charted are those of actual operation, the three tests being of from 125 to 136 hours duration on actual shop loads so that the results are comparable rather with that given in Table 8, viz: 2.015 pounds coal consumed per kilowatt hour, than with the brief "holder drop" tests of Table 1, or the 51 hour test. The best result at Richmond was 1.653 lb. of Pocahontas coal per kilowatt hour, on a fluctuating load which averaged slightly over the generator capacity. The efficiency from coal as fired, to bus-bars, was about 14 per cent. This may be compared with the figure of 10.3 per cent recently given for one of the largest and most economical of our steam power plants. The thermal efficiency of the engine was close to 25 per cent.

2 There is nothing gained by comparing these curves with those of steam engines. As is pointed out in the paper the total hourly fuel consumption, Fig. 2, is represented by a nearly straight line. Without mechanical losses, the efficiency curves of the accompanying diagram would be nearly horizontal lines. The greater preponderance of the effect of mechanical losses at light loads gives these curves their inclination and curvature. We might select for comparison a steam engine having very low mechanical losses—a simple engine.

It would give a better efficiency curve, of course; but if we selected a more economical type of steam engine, the mechanical losses would be higher and the efficiency curve would not be as good as that of these two gas engines; still it would on the whole, be more efficient than the simple engine. As far as thermal efficiency is concerned, the

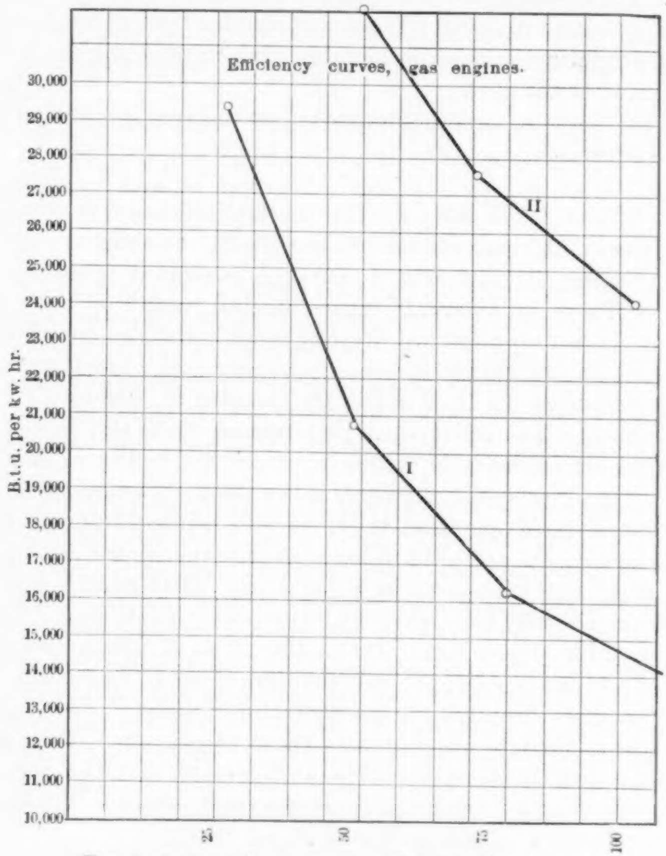

Fig. 1 Curves Showing Gas Engine Efficiency

total hourly fuel consumption, charted as a nearly straight line in Fig. 2, shows it to be almost constant; in the Richmond tests it was still more nearly constant. In order that such gas engines may have efficiency curves equal to those of the best steam engines, it is therefore necessary only that the mechanical losses be as low. Mechanical efficiencies of 83 per cent, as given in *f*, Par. 3, certainly give no ground for apprehension in this respect.

CONTROL OF INTERNAL COMBUSTION IN GAS ENGINES

By Prof. C. E. Lucke, Published in Mid-November Proceedings

Mr. R. E. Mathot Without wishing to detract from the very valuable report presented by Professor Lucke, I would like to discuss some phenomena shown by the indicator diagrams reproduced in his paper. Unless a special study of such cards is made, it is difficult to determine whether the irregularities in diagrams are due to special phenomena occurring in the gas engine cylinder, or are simply the result of faulty operation of the indicator itself.

2 For instance, in Fig. 4, I do not agree with Professor Lucke's statements regarding the curves in the upper expansion lines. These undulations are not due to waves in the burning mixture, but are caused by the inertia of the indicator piston and usually appear when the indicator spring is too heavy for the running speed.

3 Fig. 11 shows a different form of wave in the beginning of the expansion curve, such as generally obtained when preignition or very sharp and severe explosions take place, either in the cylinder or in the indicator. In the latter case, a common phenomenon, very rapid vibration, is communicated to the tracer, and to the moving lever of the indicator.

4 When a powerful explosion takes place, as the result of the combined effect of preignition and too rich mixture, the top of the initial pressure line, instead of being smooth, is really a dotted line, showing that the tracer was vibrating on the paper.

5 In order to determine and locate such troubles, I use a special attachment, consisting of a short tube fitted in the indicator cylinder, immediately under the piston. This tube prevents the piston from moving in the lower part of the cylinder, and as a consequence the tracer will only record the upper part of the diagram, thus showing the top of the explosion line and the beginning of the expansion line. The stroke of the moving parts of the indicator being reduced to a minimum, they will no longer be subjected to inertia, and cards like Fig. 4 and 17 will show regular lines without waves, evidently proving that this wave phenomenon has taken place, not in the engine, but in the indicator itself.

6 Let us now consider Fig. 7 and 8, showing from eight to ten undulations while expansion takes place; that is, during one-half revolution of the engine at a minimum speed of say 200 r.p.m. If the undulations really represent wave effects, the indicator should give true and accurate records, even when used on an engine running at

2 by 8 (or 10) by 200 = 3200 to 4000 r.p.m. while it is well known by experienced testers that, no matter what indicator makers may claim, no instrument of standard construction will give reliable information on gas engines turning higher than 450 to 500 r.p.m.

7 With reference to faulty indications given by this apparatus, I might also mention the apparent "scavenging" shown by an exhaust line traced under the atmospheric line, when a weak spring or a stop of the piston of the indicator is used to record the back pressure and the vacuum.

8 From the examination of these so-called "vacuum cards" many makers claim that their engines are "scavenging," while the diagram shows merely an inertia effect of the moving parts of the indicator that have caused the exhaust line to show a vacuum.

9 In fact, in the study of about 500 tests, made since 1900 on all sorts of engines, I have perhaps found 20 or 25 cases where scavenging really occurred in the engine's cylinder.

10 Experience has shown how to determine the right spring to use with a good indicator for recording both true vacuum and back-pressure. This spring should have about a 25 lb. scale, just strong enough to overcome the inertia of the moving parts, and light enough to record distinctly both vacuum and back-pressure, as compared with the atmospheric line.

11 I do not wish, however, to deny the existence of explosive waves of the nature of those mentioned and demonstrated by Professor Lucke's experiments. I would add, that physical properties such as lack of homogeneity in the mixtures, may generate explosive waves, or more accurately, waves in the explosions. These factors are of a mechanical nature such as vibrations in the walls of the combustion chamber and in the flat bottom of the piston when sharp and sudden explosions take place. The waves are usually generated from very rich mixtures, which have a tendency to preignite or to fire early, as for instance, when the piston is at dead center and almost momentarily at rest. If these metal vibrations happen to synchronize with those propagated in the fluid, waves result that may be detected in the diagram.

12 I wish Professor Lucke would continue his interesting experiments on larger engines, since they would surely result in a contribution to the subject.

ENGINE DESIGN ADAPTED FOR THE USE OF SUPERHEATED STEAM

By Max E. R. Toltz, Published in September Proceedings

Mr. R. T. Ode We probably have had as much to do with superheated steam engines as any other manufacturer in this country; we have at the Lancaster Railway Company's main central station, three 1500 h.p. superheated steam engines, one 600 h.p. cross compound engine at Millbourne Mills, a report upon which was presented to the Association by Professor Jacobus, and several others of from 500 to 1500 h.p.

2 Our experience has been that it is profitable to use a moderate degree of superheat in cases where service is continuous. This degree of superheat is not limited to any feature of design, but is because of the slight gain that can be obtained in the coal consumption. We found that high temperatures distorted the cast iron cylinders, and that it took about six weeks operation before the cylinders took final shape or set. In our designs we are very careful to leave nothing on the cylinder barrels that may cause unequal expansion or distortion.

3 We find that poppet valve engines cost about the same as the ordinary Corliss engines. If it were not for the fixed American ideas so favorable to the Corliss valve engine, we think many manufacturers of engines in this country would now be following the European practice, for the performance of the poppet valve engine is most satisfactory.

4 In regard to the floor space and cost of the entire plant, we find that in the superheated steam installation the smaller quantity of steam required to develop the same power, as compared with the saturated steam engine, offsets the difference there is in the floor space and extra cost of the superheater, inasmuch as the boiler capacity required is less.

5 In regard to piping equipment, we find that the same features suggested in regard to the design of the cylinder apply here also. If we take care with design we have no trouble from distortion.

6 As we are the introducers of the Schmidt system in America, we are very much interested in the results shown in the table.

7 I notice there are three sheets of results given, and I do not know whether they are compiled directly from actual tests or tabulated from a few tests. I would like Mr. Toltz to tell us about that. I think these tables are of more value than anything else we have on the subject.

Mr. J. A. Seymour It would seem to be very important to emphasize the fact, which is referred to only indirectly by the author of the paper, that the possible increase in economy from the use of superheated steam comes from two sources:

a From the increase in range of temperature limits between which the engine works.

b From the decrease in the amount of heat by-passed around the working cycle through heat transference to and from the cylinder walls.

2 This heat transference is called by the author "cylinder condensation," as is customary, but the term is misleading. What is meant by "cylinder condensation" is condensation by reason of heat being given up by the steam to the cylinder walls during the early part of the stroke when the steam is hotter than the cylinder walls. Steam is also condensed at a later period during expansion in the cylinder in order to supply a sufficient heat equivalent to the work performed. This is not a source of loss of economy, but a gain, and in actual practice the more economical the engine, the greater the amount of condensed steam in the exhaust.

3 When the range between the high and low temperature limits in any heat engine is increased, conditions are secured which, with an ideal engine would give increased economy. Practically, there is only a comparatively small saving in the economy of the engine from this source when using a high degree of superheat which to many of us, does not seem to compensate for the resulting decrease in the efficiency and reliability of the remainder of the plant.

4 In regard to the saving from the second mentioned source, Professor Unwin pointed out, a good many years ago, that the effect of superheat in lessening the transfer of heat to the cylinder walls before expansion takes place and back again to the steam during the exhaust stroke, was very considerable for a comparatively small amount of superheat, but that, as the superheat was increased, the corresponding increase in this effect rapidly diminished and that the increased saving was not worth while for a superheat higher than from 100 to 120 deg. fahr.

5 One of the difficulties encountered with high superheat is cylinder lubrication. With moderate superheat there seems to be no greater difficulty in this respect than with saturated steam and perhaps, on the average, rather less difficulty. When you have very wet steam, especially with bad feed water, there will be more trouble with cylinder lubrication than with steam moderately superheated.

6 Valve troubles with superheated steam generally come from the distortion of the valve by reason of high temperature. Eight or nine years ago the regular form of unbalanced gridiron valve, such as was used on McIntosh & Seymour engines, was tested with highly superheated steam, with the expectation that some other form of valve should possibly be adopted where superheat was used. The test showed this type of valve to be suitable in every way for use with highly superheated steam. Since that time some thirty-odd engines put out with this type of valve and aggregating 75 000 h.p., are running with superheated steam, and no difficulties whatever have developed. In none of these engines has the superheat been higher than 125 deg. for the reason, as explained above, that it was not thought that there would be any practical gain, all things being considered, by increasing the superheat above this point. With this degree of superheat no troubles nor drawbacks whatever have been experienced, either in the engine or elsewhere in the steam plant.

7 One of the principal reasons why these gridiron valves have given no trouble with superheated steam is that the seats are very stiff and the valves themselves are comparatively limber, so that the form of valve will easily follow that of the seat in case of any change in shape due to the high temperature. With superheated steam it is of the greatest importance to adopt a form of valve which, if distorted by a high temperature, will not stick or leak, and it should not be assumed that the double poppet valve is the ideal valve for this service. There are two large power plants in New York, the Interborough and the Manhattan Elevated, where the engines in both stations were built by the same concern and are, in general, similar in all respects, except that in one station double poppet valves are used on the high-pressure cylinder, and in the other, ordinary Corliss valves. It is currently reported that the poppet valves are not as tight as the Corliss valves in the older station, and that the poppet valve engines do not give as good economy.

8 It is not fair to compare the performance of a Sulzer engine with that of the average American engine The Sulzer engine is built with a refinement of detail and a perfection of workmanship that would be commercially impossible in this country. This refinement makes possible a fine performance in spite of details, which, especially if designed for the usual conditions obtaining in power plants in this country, might be bettered. The writer greatly admires the Sulzer engine and its performance, but believes that it might give still better economy with some other form of valve.

9 The economy of an engine using superheated steam should not be given in pounds of coal which combines with the engine performance that of the steam generating and superheating part of the plant nor in pounds of feed water, for both methods make comparisons with other engines very misleading. It takes a good many more heat units to transform a pound of feed water into highly superheated steam than into saturated steam. The economy of the engine should be stated in terms of the number of thermal units added to the feed water per unit of work, in the manner recommended by the Committee on Tests of this Society. By this means the apparently large percentages saved by the use of highly superheated steam, on the pounds of feed water rating, will be very considerably reduced when the correct rating is used.

10 It is not possible to give examples of this from the author's paper, since in the tests quoted he does not give the vacuum. Below are comparisons from published tests of an engine, made both with saturated steam and with highly superheated steam, and also of another engine running with a moderate degree of superheat.

Pounds of steam per i.h.p. with 374.5 deg. superheat	9.56
Pounds of steam per i.h.p. with saturated steam	13.84
B.t.u. per i.h.p. per minute with 374.5 deg. superheat	203.7
B.t.u. per i.h.p. per minute with saturated steam	248.2
Apparent saving with 374.5 deg. superheat on basis of pounds of steam supplied to engine, per cent	30.9
Actual saving with 374.5 deg. superheat on basis of B.t.u. supplied to feed water, per cent	17.9
Pounds of steam per i.h.p. with 92.3 deg. superheat	11.21
B.t.u. per i.h.p. minute with 92.3 deg. superheat	209.6
Apparent saving with 374.5 deg. superheat compared with 92.3 deg. superheat on basis of pounds of steam supplied to engine, per cent	14.7
Actual saving with 374.5 deg. superheat compared with 92.3 deg. superheat on basis of B.t.u. supplied to feed water, per cent	2.8

11 These results are only intended to show the fallacy of making comparisons on the basis of economy ratings given in pounds of steam supplied to the engine, and they have no bearing on the comparative economy of the various degrees of superheat given, on account of the dissimilarity of the conditions in the tests quoted. The results are given on the basis of the Regnault valve of 0.48 for the specific heat. The comparative savings are only slightly affected if the more correct values of Professor Thomas are used.

MR. I. E. MOULTROP The total temperature of the steam is one of the most important considerations in this discussion.

2 The writer had experience, for some ten or twelve years, with the use of superheated steam in large power plants. About 1896 the Edison Electrical Illuminating Company of Boston increased the capacity of one of their power plants. Four 400 h.p. Babcock & Wilcox boilers were installed in the fire room, equipped wth the Babcock & Wilcox attached type of superheater, designed for 125 deg. fahr. superheat. These were connected to the pipe mains already installed, in parallel with seven boilers of the same size without superheaters. In the engine room were some vertical triple expansion engines with piston valves, and one or two vertical compound engines of the type Mr. Seymour mentions, equipped with gridiron slide valves.

3 We did not know much about the use of superheated steam at that time, and made this installation partly as an experiment. We expected to have some trouble with cylinder lubrication and also with packings, etc., but other than changing the grade of cylinder oil for one adapted to the higher temperature, which did not materially change the cost, none of the anticipated troubles developed.

4 Of course, with the small number of superheaters installed the total temperature of the steam at the engines was not very much in excess of the temperature for saturated steam at the boiler pressure.

5 During the next few years, eight similar boilers with superheaters and a few more vertical compound engines of the gridiron valve type, were installed at the station. The subsequent installations were made in such a way that boilers with superheaters were run separate from those without, so that the total temperature of the steam at the engines would run up to about 450 deg. fahr. This later installation has been in use seven or eight years, and we have yet to experience any of the anticipated troubles due to the use of superheated steam.

6 About five years ago we built a large turbine station using the same type of boilers and superheaters, except that here the steam pressure was 175 lb. and the superheaters built for 150 deg. fahr. of superheat. This nominally gives a temperature of steam of about 525 deg. fahr., but while the boilers are being forced during the peak of the load, the total temperature of steam probably reaches as high as 600 deg. fahr. at times.

7 We have found that under these conditions there are things to be watched. In some instances we believe we have found evidence of the deleterious effect of superheated steam on cast iron, which has been mentioned in the previous discussion, and we think the same may

be true in a measure in reference to gun iron. We are also pretty well satisfied that brass or copper are not good materials to bring in contact with superheated steam. No special difficulty was encountered in the lubricating of the auxiliaries at this higher temperature, but there does seem to be a question as to whether there is any economy in carrying the superheat beyond this amount.

PROF. WM. KENT The discussion seems to have rambled all over the question whether we shall superheat steam or shall not superheat steam. Now, the vital question is, assuming that we are going to have highly superheated steam, 625 deg. fahr., shall we use the poppet valve, or the gridiron valve, or some other valve? Mr. Seymour, I think, is the only one who has discussed this important question. Can we not have some more discussion on it?

THE SPECIFIC HEAT OF SUPERHEATED STEAM

BY PROF. C. C. THOMAS, PUBLISHED IN DECEMBER PROCEEDINGS

MR. A. R. DODGE The paper by Professor Thomas shows a marked advance in the method of determining c_p by electrical methods. There are several points concerning which the writer is in doubt which can probably be explained by the author.

2 Referring to Par. 52 and Fig. 19, it should be noted that the values of total heat for saturated steam are from steam tables. These values are not thought to be sufficiently accurate to determine the constant heat curves *BB*.[1] Replotting these curves using for instance the total heat values given in the writer's paper on c_p, Par. 51, Fig. 11, Proceedings A.S.M.E., April 1907, regular curves are obtained which show similar characteristics. Fig. 11 of my paper has recently been extended to include constant heat curves up to 1400 heat units, and no such irregularity as mentioned by Professor Thomas appears. As a slight error in the total heats of saturated steam causes a marked change in the characteristics of these constant heat curves, irregularities in the curves *BB*, Fig. 19, are not conclusive. Even if we assume the values of total heat from steam tables to be correct, the black points mentioned in Par. 36 show reversed curvature at high total heats.

[1] Peake, Proceedings of Royal Inst., June 28, 1905, p. 201. Denton, Stevens Indicator, October 1905, p. 383.

3 It is not clear whether the cold end of the thermo couple was kept at exactly constant temperature. Similar measurements of steam temperature by the writer show errors, unless each element of the thermo couple extends in one piece to the cold end, or unless the junctions between the couples and the extension piece to the cold end are sufficiently remote to prevent heat reaching them from the hot end by conduction.

TABLE NO. 1

COMPARISON OF SPECIFIC HEATS AT THE SAME TOTAL HEAT

1 Total heat value	2 Superheat at 15 lb. abs.	3 Mean c_p at 15 lb. abs., Thomas	4 Corresp. superheat at 590 lb. using throttling calorimeter	5 Mean c_p at 590 lb. abs., Thomas	6 Mean c_p values substituting Col. 3 (c_{p_2}) in equation $\frac{c_{p_1}}{c_{p_2}} = \tan.\ \alpha$
A	0	.657			
B	25	.559			
C	50	.530			
D	100	.507			
E	150	.496	17	.691	.682
F	200	.491	55	.635	.676
G	250	.487	92	.613	.670
H	300	.485	129	.598	.667
I	350	.483	169	.586	.665

TABLE NO. 2

COMPARISON OF SPECIFIC HEATS AT THE SAME SUPERHEAT. DERIVED FROM TABLE No. 1

1 Superheat deg. fahr.	2 Mean c_p values 15 lb. abs., Thomas	3 Mean c_p values 590 lb. abs., Thomas	4 Mean c_p values substituting Col. 2 (c_{p2}) in equation $\frac{c_{p_1}}{c_{p_2}} = \tan.\ \alpha$
0	.657	.840	.686
50	.530	.639	.677
100	.507	.609	.670
150	.496	.591	.666
200	.491	.578	.663
250	.487	.567	.661
300	.485	.559	.660

4 The straight line relation, as determined in Fig. 8 of the writer's investigation, using superheated steam on each side of the calorimeter, establishes the following:

5 The value c_p varies with pressure in such a manner that at constant total heat $\frac{c_{p1}}{c_{p2}} = \tan.\ \alpha$, where c_{p1} is the mean specific heat for any pressure and c_{p2} is the mean specific heat for any fixed pressure (15 lb. in Fig. 8), and tan. α is a constant for any given pressure. Therefore, c_{p1} and c_{p2} may or may not vary with superheat at constant pressure.

6 The ratio of the specific heats, however, at any two pressures, and at the same time the total heats, must be constant.

7 Taking the mean values of c_{p2} at 15 lb. absolute, given by Professor Thomas for different degrees of superheat in Fig. 7, and multiplying these values by the ratios $\frac{c_{p1}}{c_{p2}} = \tan.\ \alpha$ found by the writer between 590 lb. absolute and 15 lb. absolute, we obtain mean values of c_{p1} for 590 lb. absolute. These are compared in the preceding tables with the values determined by Professor Thomas and are seen to differ considerably.

8 The radical difference between the present values of c_p given by Professor Thomas and those published by Professor Carpenter in November 1906,[1] using the same general method, as well as the marked discrepancy between all authorities emphasizes the desirability of a thorough investigation of the specific heat of steam by this Society which should include a complete revision of the steam tables.

Dr. Sanford A. Moss Professor Thomas is to be congratulated on the completion of this work over which he has been engaged so long and patiently. I understand this is a final announcement of the work, superseding previous preliminary reports. The following is my understanding of the method by which the final results are obtained. I would like to inquire if this is correct.

2 Fig. 9 represents the final set of experiments practically equivalent to some others and taken as exactly representing all of the experimental work. Fig. 16 gives the same values, with change of vertical scale. The values of Fig. 16 for zero pounds are obtained by a process of fairing. If there were any sudden changes in the laws for

[1] Steam Plant of the White Motor Car, Vol. 28 Trans. A.S.M.E.

very small pressures, the exact intersections with the axis for zero pounds pressures would not be correct. By plotting the various values given on a vertical line in Fig. 16 against temperature, Fig. 17 was obtained. The figures on the curves in Fig. 9 and Fig. 16 represent degrees of superheat. The ordinates of Figs. 16 and 17 give total heat of superheated steam above saturation point, including the actual or intrinsic energy present in the steam, as well as the external work done by change of volume at constant pressure. Fig. 5 and 6 are obtained by drawing tangents to the constant pressure curves of Fig. 17 or by some process equivalent to this, since it can be shown that specific heat at some constant pressure is rate of change of total heat. Fig. 7 and 8 were obtained from Fig. 17 by dividing ordinates by abscissae. In drawing the Mollier diagram of Fig. 21, I would like to inquire if Professor Thomas has assumed Regnault's well-known formula for total heat of saturated steam:

$$\lambda = 1091.7 + 0.305\ (t - 32)$$

3 I have heard some doubt expressed as to the exactness of this formula. As I understand it, Professor Thomas' experiments do not completely give the total heat of superheated steam above water at 32 deg. since they give no information or indication concerning the total heat of vaporization, but only give total heat above vaporization point.

4 The method which Professor Thomas uses of finding specific heat for zero pressure indicates that it is variable. There are strong, although not positive theoretical reasons, for believing that the specific heat of any gas at zero pressure is constant for all temperatures and is equal to the theoretical value given by molecular weight in comparison with hydrogen. Furthermore, the lowest pressure for which Professor Thomas took observations, seven pounds, is not very nearly zero pressure.

5 There is a vast difference between pressures which are practically zero and seven pounds pressure, as may be seen from the corresponding differences of volume. For instance, the volume at 0.07 lb. pressure is about one hundred times the volume at seven pounds pressure. The volume at 0.0007 lb. pressure is about ten thousand times the volume at seven pounds pressure. It seems to me that vast differences in total heat can occur under such circumstances.

Mr. E. L. Jennings Before superheated steam was widely used, the writer used oils for lubrication containing, according to the pressure,

size of cylinder and make of engine, from 5 to 10 or 15 per cent of animal fat mixture. On superheating engines it was found that more or less gum accumulated on the valve and packing, and to overcome it, the animal fat in the hydro-carbon oil was reduced. Finally some fluid mineral oil, such as was ordinarily used on machinery, was added, which overcame the gumming. Finding that the fluid oil would be thrown out by the steam, the idea was to get as heavy a film of oil as possible on the wearing surface and get rid of the gum to a great extent (the fluid mineral simply giving legs, so to speak, to the heavier oil).

2 The writer believes that steam cylinder oil will not require a flash test over 550 deg. fahr. The so called high viscosity and flash test cylinder oil will give trouble in the cylinder in the way of petroleum tar, burnt oil or gum, as you may elect to call it.

3 As regards gas engine cylinders for automobiles or stationary engines, an oil that will go off in smoke should be used. The flash test of any gas engine cylinder oil should not be over 350 to 400 deg. fahr; otherwise, carbon or tar will get in the cylinders. After an oil is distilled, it should be cleaned by filtration, instead of being treated with sulphuric acid. This is very important. Cylinder oil suited to saturated or superheated steam is not at all adapted to gas engines or automobile cylinders.

COLLEGE AND APPRENTICE TRAINING

By Prof. J. P. Jackson, Published in October Proceedings

Mr. Bassett Jones, Jr. The Morrill Land Grant Act states that such State institutions as may be founded under the terms of its provisions shall be organized "to promote the *liberal and practical* education of the industrial classes." Perhaps without the intention of the promoters of this act, this unfortunate bifurcation of the object of education has become an established fact. Colleges for the inculcation of a so-called "liberal education" have, both in meaning and results, become distinct from the technical schools providing a specialized education in purely technical fields.

2 A liberal education is practical when it gives the student an altruistic aim and purpose in life, regardless of the particular field to which his energies are devoted. A technical education that is not liberal in this sense is not practical. The time is ripe for us to give a broader meaning to the term practical, when used in connection with education than that generally applied to it by public opinion.

3 The so called liberalizing studies should not be made separate from professional studies, but connected with them in every possible way. Political and social economics, for instance, have been deeply affected by the advance of science and engineering, and this aspect of these topics is the one to be accented in schools of technology. The engineer has also perhaps been the prime maker of modern history. The study of engineering history and its bearing on the solution of modern engineering problems has been strangely neglected, yet the historical method is likewise the method of engineering, and, in fact, the only sane method of attacking problems so deep in their effect upon society as are those of engineering science.

4 Technical teachers complain that perhaps two-thirds of the student course is now given over to subjects not connected with engineering, and that any further broadening of the course of study would be positively injurious. But is it not a fact that the primary difficulty lies rather in the approach than in the material? There is too little emphasis on the *connection* between those studies that are purely technical and those that are not. Each teacher specializes too much in his own field without any consideration of the relations of his subject to those that the student is mastering at the same time. "Why," says the student, "am I required to study history in an engineering school." And he gets no answer to his query because he is not made to see the utility of historical study in his professional work and life.

5 Professor Jackson shows precisely one of the weakest points in engineering education of today, namely, that our schools, failing to liberalize the student's conceptions of nature by direct contact with practical life problems, have been supplemented by what in effect is a post-graduate course organized with a view to remedy this defect.

6 The question is whether it would not be possible to organize the teaching system so that it will overcome this defect. Is it not possible to require the student to devote at least three of his four months' summer vacation to actual money making labor, under the mutual supervision of his college and employer? The material advantage gained by the student who adopts the method of supplementing the school semester by a period of actual dealing with the life conditions of his profession is very evident. He gives something which no teacher can give and no school provide—a sound judgment—without which a man is not worth his salt.

7 One great advantage of such a combination of study and appli-

cation would be to clear from the student's mind that which leads to a distinction between what is called a theoretical man and a practical man. A *theoretical man* is one who lacks definite experience in the limitations of fact. A *practical man* is one who lacks education in the development of ideas. One lacks circumference; the other lacks diameter, and the net result, in either case, is a lack of balance. A man who is to be more than a mere mechanic must have a theoretical knowledge of fundamentals. On the other hand, the man who lays claim to a special knowledge of theory—one who is disposed to jeer at experience, as many young graduates are—soon finds in the absence of controlling facts his inability to achieve concrete results.

CAR LIGHTING

BY R. M. DIXON, PUBLISHED IN JANUARY PROCEEDINGS

MR. R. E. BRUCKNER[1] The steady progress in the various branches of engineering science tending toward greater economy has manifested itself in steam engineering by the production of the steam turbine, has also been felt in the field of railway lighting, and has led to the development of various forms of car illumination superseding the old candles and oil lamps.

2 The three principal subdivisions which may be made in the present railway illumination are as follows: Pintsch gas, electricity and acetylene. Of these three systems, the one using Pintsch gas occupies the most important place and lights the greater percentage of railway cars in the United States. This is partially due to the fact that they were pioneers in the field and have been in operation for a considerably longer period than either the electrical or acetylene companies, and also because they have an admittedly good system, whose superiority over the former illuminants is not questioned for a moment.

3 The tendency of the American public to luxury in travel, regardless of cost, has created a pressure on the railway interests of this country, and forced them to consider other forms of railway car illumination affording a higher efficiency and more brilliant illumination. Various companies have devised systems for lighting cars electrically, which up to the present time, although the illumination furnished by them is good, are not reliable under all conditions. One of the main reasons for the adoption of electric lighting on railways is the statement that there is no attendant danger, or, in other words, that it

[1] Engineer, the Commercial Acetylene Company, New York.

eliminates the carriage of an explosive gas or volatile substance on a train.

4 Much has been written concerning the dangers of the use of acetylene, owing to the fact that it possesses a power of combining with metals, such as unalloyed copper, to form an explosive compound known as acetylide of copper, and the fact that it will, under a pressure exceeding two atmospheres (gage), separate into its component parts, carbon and hydrogen, such separation being attended by a great increase in volume, and, therefore, an explosion. Much of this matter has been compiled without sufficient research, and, whereas these statements are in part true, the common acceptance of them exaggerates their importance. For instance, acetylide of copper can be formed by the action of acetylene on copper salts, but it has been conclusively proved that this action can not take place under service conditions, even with impure gas, as the formation of this compound requires the presence of ammonia in excess and a heat approximating 200 deg. cent. (Experiments of Bullier, Berthelot and Dr. Stillman.) Assuming that acetylene gas was stored in an empty cylinder to a pressure of ten atmospheres, and that any one of these cylinders, owing to fire, should be heated to 1436 deg. fahr., the dissociation of the entire volume of gas within the cylinder would be produced, and the explosion of the cylinder would follow.

5 It has also been found that, should ignition occur within the receiver containing free acetylene gas under a pressure of ten atmospheres, this ignition is communicated immediately to the entire volume of gas, thereby causing similar results. Research has also proved that this ignition can not be communicated through very fine apertures, such as burner orifices, or finely divided substances, such as asbestos, kiesel-guhr, infusorial earth and unglazed brick. These substances possess a porosity or cellular air space of 80 per cent, and the interstices are of such minute caliber that the transmission of flame through them is impossible.

6 The researches of Claude and Hess toward a practical and safe method of storing compressed acetylene have led to the use of acetone, a combustible organic liquid of high solvent power, and a cylinder completely filled with some inorganic porous material. Acetone boils at 56 deg. cent. or 133 deg. fahr., and at a temperature of 60 deg. fahr. possesses the power of absorbing 25 times its own volume of acetylene gas per atmosphere. This method has been utilized in England, in France and in the United States in a commercial way. In both England and France, owing to the high price of asbestos as a

packing material for the cylinder, a mixture of infusorial earth, charcoal, oxid of zinc, and chlorid of zinc, is employed, as a porous filling for the cylinder. This material forms a paste, which, upon being dried resembles chalk, which possesses a porosity or cellular air space of 80 per cent, and its cells are of the most microscopic proportions. In the United States the cylinders are packed from end to end with asbestos discs, the structure of which is obtained by building up the discs of asbestos fiber, cemented together with silicate of soda. These discs have the same porosity as the French mixture, but possess the immense advantage over the latter of never breaking under shock or vibration.

7 The storage cylinder then, as supplied by the Commercial Acetylene Company, consists of a steel shell 20 in. by 114 in., which is filled from end to end with asbestos discs packed in such a manner as to allow absolutely no free space within the cylinder. This asbestos filling, which is absolutely inert in the presence of acetone, is then saturated with the latter, the liquid acetone being absorbed by the asbestos packing and thoroughly saturating it. In so doing the acetone itself is in very finely divided particles and offers a maximum absorption surface, the gas being then held in a multitude of minute cells, each one of which is separated from the other by capillary apertures. The propagation of a flame or a shock through the entire mass is a physical impossibility.

8 Experiments conducted to demonstrate this fact have shown that an electric spark may be passed through a charged cylinder, and it will only produce local ignition involving perhaps a cubic inch, and there burn itself out without in any way affecting the remaining gas in the cylinder. It is also necessary to provide for the liberation of the gas contained in the cylinder in the event of this cylinder passing through a fire where it is highly heated on its exterior. This is accomplished by placing three or more fusible plugs, which melt at a temperature of 300 deg. fahr. in the shell of the cylinder. It has been found that these plugs melt long before any excessive pressure has been formed inside the cylinder, due to expansion by heat, and that as soon as they melt out, the gas escapes and burns as from a torch nozzle, completely emptying the cylinder of its contents without explosion.

9 As further proof that these precautions thoroughly safeguard the cylinder from explosion, three instances may be cited: In one case ten cylinders, fully charged, were put in a fire of half a cartload of wood and 20 gallons of gasolene poured over it. Not one of the

cylinders exploded and everyone emptied its contents perfectly. Second, the yacht Vagabond, which was equipped with the Commercial Acetylene Company's system, was burned to the water's edge and then sank in the Hudson river. When the hull was raised, both cylinders were found to be intact, despite the fact that they had been heated to redness and then plunged into cold water. Third, a car on one of the roads equipped with our system, furnished with three small tanks to feed two powerful reflectors and which was used as an inspection car, was completely consumed by fire, nothing remaining but the trucks and floor beams. After the fire the three cylinders were found empty of gas, the fuse plugs having blown, but no explosion having taken place.

10 One of the principal advantages secured by this method of storage is the immense amount of gas which may be carried in a small space. The standard Pintsch tank, measuring approximately 20 by 114 in., contains at a pressure of ten atmospheres about two hundred cubic feet of gas. A cylinder of the same size, packed with asbestos and charged to about 40 per cent of its volume with acetone, contains, at a pressure of ten atmospheres, 2000 cu. ft. of acetylene gas, representing 100 000 candle power, which, at an average daily consumption of 40 cu. ft. per car, gives a service of 50 days without recharging. This enables a railroad operating long distance trains to erect one charging plant, located perhaps at the Atlantic coast, and to send its cars from here to San Francisco and back five times without recharging.

11 The production of acetylene gas is one of the simplest of manufacturing processes, carbide being merely dropped into water immediately liberating acetylene gas, which is then stored in an ordinary gasometer, and led from there through suitable driers and purifiers to a three-stage water cooled compressor where it is raised to a pressure of 150 lb., then stored in cylinders of the same construction as those used on cars, and thence piped throughout the yard to the various tracks where cars are to be gased. In order to get the full charge of gas into the cylinder, it is necessary to permit the pressure to settle, as the acetone does not immediately take up its full complement of gas, but with a charging period of five to ten minutes, and a storage battery pressure of 150 lb., 1200 ft. may be put into a cylinder, or enough to operate it for 30 days. The extreme simplicity of manufacture, compression and delivery of this gas is best shown by the fact that at the present time the New York, New Haven and Hartford Railroad Company, operating approximately four hundred cars

employs one man at their charging plant, who not only makes all the gas and compresses it, but also charges all the cars now operated by this system. Also the Delaware, Lackawanna and Western Railroad Company, using both the Pinstch system and the Commercial Acetylene system, operates its acetylene plant, which supplies 150 cars, by having their Pintsch superintendent devote two or three hours a day to the acetylene plant. The ground space occupied by a plant capable of supplying 500 cars is 46 ft. by 30 ft., and by the addition of a little more apparatus, not increasing the size of the building, this same plant will take care of 1000 cars.

12 The beauty and brilliancy of the acetylene flame is too well known to require any further discussion, and the concensus of opinion among the railroads conversant with the various forms of lighting is that at the present time, even with the unreasonable cost of carbide, it is on a par with any in price on a candle power basis.

13 The following table, taken from Leeds & Butterfield, shows the close approximation of the acetylene flame to sunlight, and the departure of the flames of various other illuminants from this standard.

COLOR IN SPECTRUM	ELECTRICITY		COAL GAS		ACETYLENE		Sunlight
	Arc	Incandescent	Luminous	Incandescent	Alone	With 3 per cent air	
Red	2.09	1.48	4.07	0.37	1.83	1.03	1
Yellow	1.00	1.00	1.00	0.90	1.02	1.02	1
Green	0.99	0.62	0.47	4.30	0.76	0.71	1
Blue	0.87	0.91	1.27	0.74	1.94	1.46	1
Violet	1.03	0.17	0.15	0.83	1.07	1.07	1
Ultra-violet	1.21						1

Mr. George R. Henderson In Par. 23 in the able presentation by Mr. Dixon he speaks of the Central Railroad of New Jersey as having put in use a car with electric lighting which was independent of a stationary plant, or independent of the other members of the train, and it seems that an ideal system requires that each car lighted should be independent of: *a*, any stationary plant; *b*, any other car or engine; *c*, any movement of the vehicle.

2 The first obviates the necessity for reaching or passing any given point, and leaves the assignment of car to traffic considerations only. The second obviates the placing of the car in a particular train

or position in the train, and leaves it free for any required service. The third obviates the necessity of running or moving the car, if it be desired to remain standing for an indefinite time, as in private or instruction cars, where it is sometimes desirable for the car to stand for a week or two, and if it is necessary to move it to supply it with light, or to attach it to another train, the lighting equipment does not satisfactorily meet the requirements. Cars independent of the enumerated conditions may be sent over foreign roads, or used as stationary apartments, and still have reliable light.

3 It is evident that few lighting systems meet these requirements. The gas and electric systems described elsewhere do not, since they depend either upon a stationary plant or wire or pipe line properly charged, or upon a sufficient movement of the car Candles and oil lamps meet these conditions, but the illumination is not satisfactory. An acetylene lighting system has, however, been recently installed which embodies all these desirable features, and also surpasses the other forms in brilliancy of illumination.

4 In Fig. 1 it will be seen that the generator is composed of a piece of twelve-inch pipe, eight feet long, which stands on end in one corner of the car. There is a can of galvanized iron, with a double grating at the bottom, about 33 in. long, in which carbide is placed. At the bottom is a valve for drawing off the residue when the material is exhausted. This has a couple of prongs which can be rotated by means of a lever to stir up the sludge, and by means of a stick it can be elevated and the liquid run out into a can placed under the car to catch the slacked lime. The top cover is secured by a nut and is removed when it is necessary to replace the charge of carbide. About one hundred and fifty pounds of carbide are ordinarily placed in a can. The size of the water tank is equivalent to a 12-in. by 33-in. reservoir. There are two pipes connecting the water tank down to the generator at a point about one-third its height from the bottom; the one extends from the bottom of the tank, and the other runs from the top with a reëntry piece extending one-third down into the tank and attached at the same height to the generator.

5 When the car is to be charged (considering one that had been in use), the first thing is to shut off, by means of a valve, the gas which remains in the storage tank. The valve is then rotated to stir up the sludge, and raised to allow the slacked lime to fall into a cart, built on wheels, to receive this material. After it is emptied, the carbide can is pulled out at the top by men on the roof of the car. If there is any good carbide in it, it is allowed to remain. When the

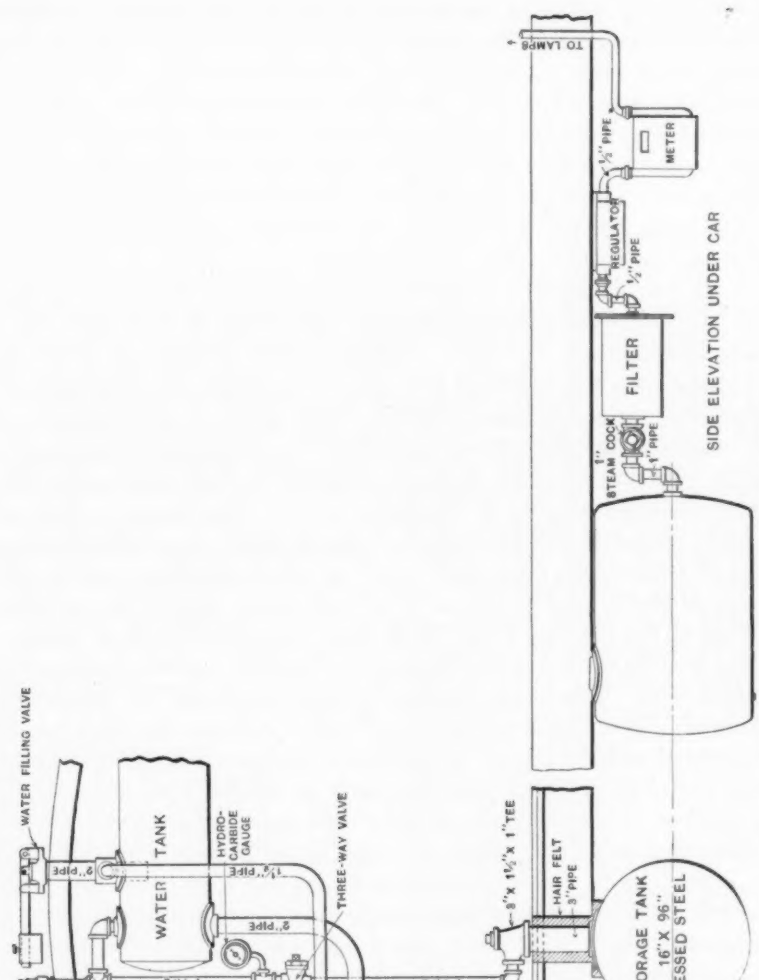

Fig. 1 Acetylene Generating Apparatus

carbide is all gone, they put in an entirely new charge, and screw on the cover.

6 Filling with water is accomplished by putting a hose through the safety valve, which keeps the valve in operative condition, because the valve must be opened whenever the tank is filled with water. As the water fills the tank it flows down into the generator, and rises to the pipe connections and fills up in the water tank until

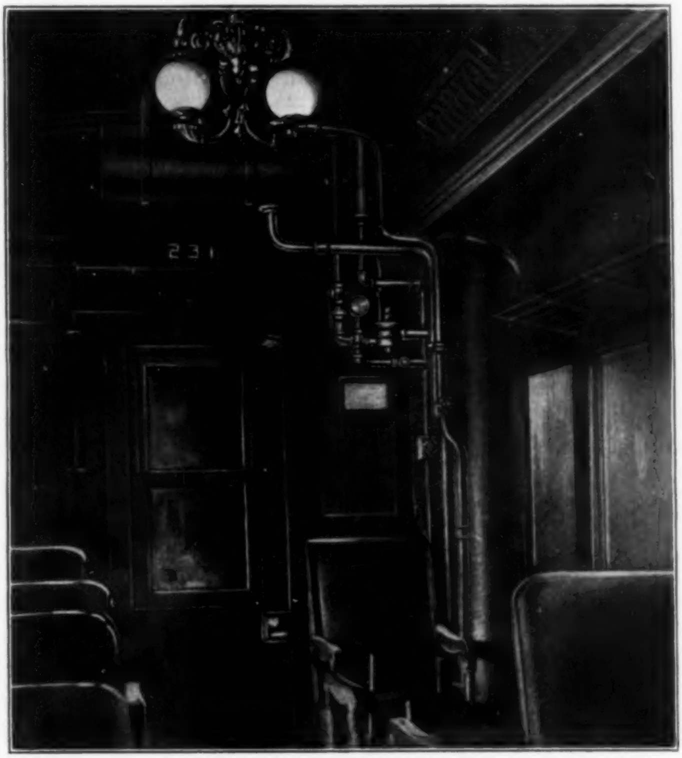

FIG. 2 INTERIOR OF CAR SHOWING GENERATING APPARATUS

it overflows. The safety valve is then closed and the water rises in the generator until it reaches the level of the carbide. Some of the carbide is decomposed, forming acetylene, and the water is driven back into the tank, preventing the further generation of gas until required. The gas passes out through a condenser to entrain any moisture, through the special equalizing valve, giving a certain regulation of

pressure (which merely regulates the flow of the water) and then it passes down through the pipe into the receiver or storage tank.

7 In this receiver the gas is carried at a pressure of two atmospheres. Passing through the reservoir it goes through a filter and regulator, which reduces the pressure to about 2.5 to three inches of water for burning. It then passes through a meter, to record how far the charge is exhausted, it being known how many cubic feet of gas are generated by 150 lb. of carbide, and then goes to the lights in the regular way.

8 Experience on the Great Northern Railroad, which has over two hundred cars equipped with this system of lighting, has proved that there is no particular danger from freezing, if properly cared for. The illumination of these lights is about thirty candle power for each five-eighths cubic foot burner, and the cars are equipped with from 12 to 48 lights, some of the dining cars having as many as 48 lights and some of the second class passenger cars as few as 12. The generation is about $4\frac{1}{2}$ cu. ft. of gas per pound of carbide, the carbide being in lumps running between $2\frac{1}{2}$ and three inches. One pound of carbide requires one-half pound of water for decomposition and slacking, and 150 lb. of carbide will run twenty $\frac{5}{8}$-ft. burners for 50 hours, and will produce 30 000 c.p. hr.

9 Mr. Flory stated that the dangers of the acetylene system were, in his opinion, very great, and Mr. Fowler spoke of some of the particular advantages of charging at the end of the line. We know that the old systems of acetylene lighting which were charged and regulated by trainmen were unsatisfactory, as there was a considerable escape of gas and a danger of ignition. In case of accident to the system the acetylene flame ran through the car and burned up everything in it; but in the system above described it is practically impossible for the gas to escape in to the car in large volume, as it is charged outside at the end of the run, and the liquid drained off at the same time. If the system should go out of commission, the only thing the trainman could do would be to light the auxiliary light. The Great Northern Railway had no trouble from explosions.

10 It was shown by Mr. Bruckner that acetylene dissociates at 1436 deg. fahr. if the pressure exceeds two atmospheres, and an explosion results. It goes without saying that any gas that will burn will explode if given suitable conditions, but with the small pressure carried in these generators (two atmospheres), even supposing that there should be such a temperature as 1436 deg. (which is considerably higher than red hot iron), there would be only a momentary increase in pressure up to about 450 lb.

11 A piece of twelve-inch pipe is ordinarily tested for 500 lb. pressure, and the gross pressure in dissociation in the generator would be 450 lb.—hardly enough to explode it. The lid or cover of the generator, previously described, is made quite light; that is, while it is tight enough for ordinary pressure, any pressure above 50 or 60 lb. would cause it to blow, and if dissociation should occur in the generator, this cover would fly off without causing any serious damage to the car.

12 The writer does not see how Mr. Fowler figured the cost of acetylene as five times that of the Pintsch light. There must be some misinformation in that respect. With carbide at $65 per ton, the gas costs about $7.50 per 1000 cu. ft., including labor and repairs, and with the cost of acetylene at $7.50 per 1000, the cost per candle power hour would probably equal the cost of the Pintsch mantle light at $5 per 1000, which is the ordinary cost of Pintsch gas.

Mr. H. K. Brooks It is a comparatively short time since there was any *choice* in the manner of lighting trains, gas being so much superior to oil for that purpose, and electric lighting not being successfully applied. The use of incandescent electric lights however, merely in an experimental way, demonstrated their superiority and the possibilities and advantages of their use. In fact, the use of electricity was relatively a far greater improvement over gas than gas was over oil.

2 The modern specifications of most of the better class of passenger cars call for electric wires to be run at the time the cars are built. There is a reason for this, and the traveling public is asking why any light with an open flame or which is the product of combustion should be used in a railway train, where every precaution for comfort and safety is expected. Where passenger lines are brought into competition and electric lights advertised, the public so appreciate and patronize the better lighted trains that the adoption of electric light quickly follows, as a matter of course.

3 The ordinary passenger coach, a few years ago, was considered properly lighted with 150 c.p. of gas light, while the earliest car equipped in this country with incandescent lights furnished 300 c.p. of electric light. Today the United States Light and Heating Company's electric system is operating on many cars in daily service on limited trains, which are equipped with 700 c.p. of electric light, and on some railway, buffet, and dining cars 800 c.p. of electric light are used in addition to power for ventilating and exhaust fans.

4 Referring to Par. 19 and 20, it gives me pleasure to find a com-

mon platform on which to stand with the writer of the paper, and to these paragraphs I would like to add that the expense of operating a dynamo driven from steam taken from the locomotive is not looked upon with favor by some railway authorities who have made it a study. Steam must be taken from the locomotive at a time when most needed, there is the expense of a skillful electrician, the fluctuations of voltage due to rise and fall of steam pressure, the high voltage generally used, the expense of maintaining flexible steam connections between locomotive and dynamo engine, and the limiting of the car service to specially equipped trains, all of which interfere greatly with the distribution and mobility of the railway car service.

5 Par. 21, relating to the use of storage batteries only. This at first glance appears to be an ideal system. Like its predecessor, however, it is limited to trains on special runs. Similar to gas, it has no self-recuperating feature and must be charged at terminals, from an outside source; it also has a limited and constantly diminishing reserve source. Unlike gas, the charging rate of batteries must not be faster than the discharge and the inconvenience and delay of cars while waiting to be charged make this method unlikely of adoption except in special instances.

6 The trend of the times is toward electric car lighting, taking power from the car axle to drive a small dynamo carried by each car, with a storage battery to furnish light when the car is at rest or below generating speed. As mentioned in Par. 23, this was first tried on the Central Railway of New York in 1890 by Morris Moskowitz. The battery is thus worked under ideal conditions and at proper intervals is being constantly replenished by the movement of the car itself. The life of the battery is thus greatly extended. It is not subject to injury from frequent disturbance or removal from the car, and considered from all sides this is proving to be the best method of lighting cars. About fifteen thousand cars have been so equipped in Europe, and several thousand in this country.

7 There are three problems which require prominent consideration with axle-driven electric equipment:

a The transmission of power from the car axle to the generator carried on the car.

b The maintenance of constant voltage or pressure of the generator, through extremely wide and varying ranges of car and armature speed.

c The maintenance of the proper polarity of generators, irrespective of direction of the car or axle.

8 It is evident that these and other functions must be automatically performed at the proper time to be of value. Time will not be taken to consider problem *a* and I will pass at once to problem *b*.

9 In the United States system a constant voltage is maintained by shunting the current from the shunt field of the generator through a series of carbon resistance discs, the resistance of which is varied by pressing the discs together to a greater or less degree. This principle is new and has been so acknowledged by the patent offices in this and in foreign countries.

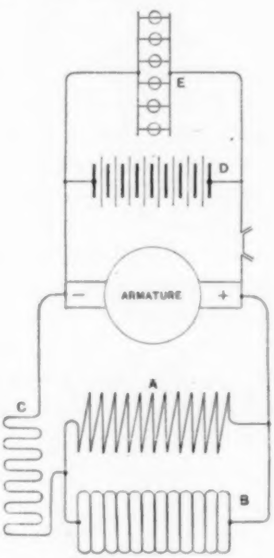

Fig. 1

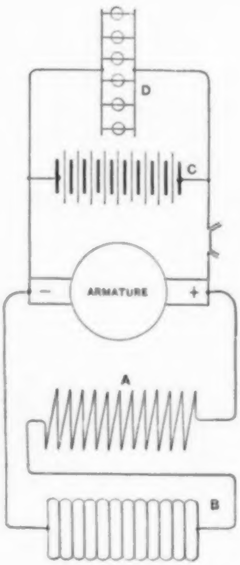

Fig. 2

Fig. 1 Diagram of United States Light and Heating Company's System
Fig. 2 Diagram of System with Carbon Discs in Series

10 Fig. 1 shows the United States system in diagrammatic form; comprising the generator with its shunt field winding *A*, its compressible discs *B*, which are of high resistance, its fixed resistance unit *C*, its battery *D*, and lamp circuit *E*.

11 The generator armature requires a powerful shunt field when revolving at low speeds and when the resistance discs *B* are not under compression all of the exciting current is compelled to pass through the shunt field *A* and fixed resistance unit *C*, thereby permitting the generator to yield its full current output at exceedingly low speeds of car travel.

12 When, however, the armature rotates beyond the predetermined speed required for its fixed output, pressure is automatically applied to the resistance discs *B*, thereby shunting or leading the exciting current from the field winding *A*, through the resistance discs *B*.

13 It will be seen from this that a rational method of field regulation is obtained in this new and original manner. The range in the compressible discs is here really immaterial (so far as perfect regulation is concerned under the highest armature speeds), as the compression on the discs *B* is applied when the output of the generator is to be held down against high armature speed, and a limited range in the compressible discs can in no way affect the perfect regulation of the generator under the highest speeds a train may attain.

14 If the compressible discs should actually become fatigued under compression the only detrimental result would be that the generator would yield its full output at a slightly higher speed of the train; whereas, under this condition in other systems; Fig. 2, with carbon discs in series with the shunt field *A*, the generator would not be regulated under the high speeds, thereby permitting the voltage and current to rise beyond the normal, and practically making the generator an unregulated machine under the high speeds. Again, in Fig. 1, any rupture taking place in the compressible discs *B* would in no way interfere with or open the field winding *A* of the generator.

15 Fig. 3 represents the United States Light and Heating Company's automatic regulator and switchboard. The lower coil on the left is composed of a certain number of convolutions of heavy wire through which all the current generated passes on its way to lamps or batteries. An iron plunger floating in the magnetic field of the solonoid is acted upon by the varying strength of the generator current, being pivoted on a lever balanced against a spiral spring (contained in the small case at the right). Any attempt of the current to rise against the predetermined pull of the spring causes pressure to be brought on the two stacks of carbon discs, which constitute a by-path or valve shunting from the dynamo field the proper proportion of current necessary to hold the output of the dynamo constant under widely varying armature speeds.

16 This apparatus avoids the complicated mechanism, small motors, levers, pawls and ratchets commonly used for this purpose, by employing these carbon discs. The two coils at the top, Fig. 3, are for the automatic battery switch. There must be an automatic arrangement provided to put the lamps in circuit when the car stops

and to connect the lamps and batteries with the dynamo when the car attains a speed above fifteen miles an hour.

17 This switch is magnetically arranged with a shunt winding on the two coils, which attract the steel armature and the switch at the proper moment. A series winding then comes into play to intensify the pull on the switch and also to demagnetize these coils when the

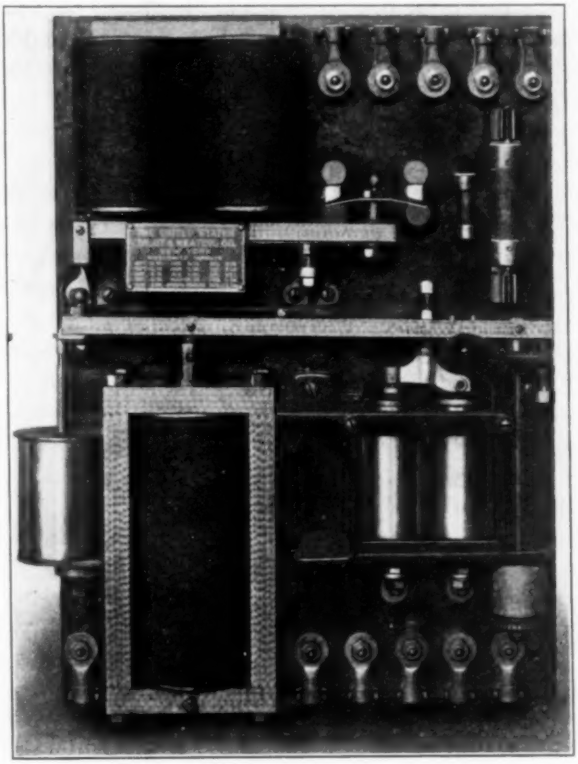

FIG. 3 AUTOMATIC REGULATOR AND SWITCHBOARD

armature current stops, and the battery current reverses. If the switch should fail to open, the battery current would attempt to drive the dynamo as a motor and drive the car.

18 Much energy and zeal have been displayed during the past few years in the development of switches of this kind. Some are fitted with carbon "breaking points" and other mechanism which gives a great deal of trouble. This switch is simple because of its

good design, principally, and because it opens by gravity at the time when there is practically no current flowing. We have never had any trouble with this switch.

19 Now passing to the third problem of the maintenance of the proper polarity of the generator, irrespective of the direction of motion of the car axle. This is accomplished by the automatic polarity changer. In the earliest type, which is still used by several companies, the generator brush holders are mounted on a ring which is carried on ball bearings. Eight brushes are used, and these are held tightly against the commutator by springs.

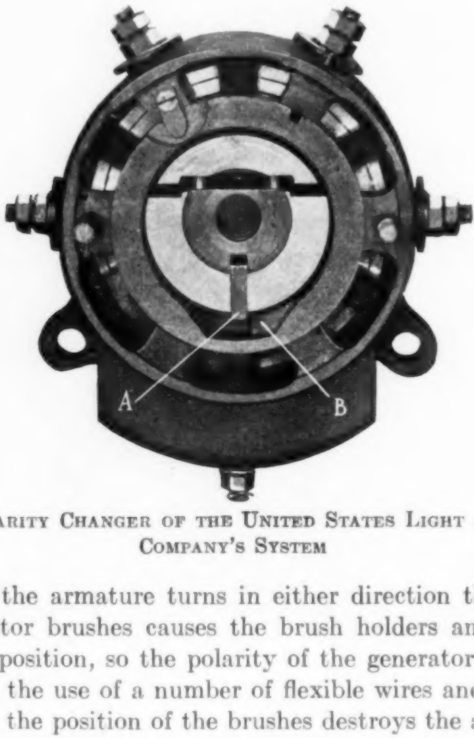

FIG. 4 POLARITY CHANGER OF THE UNITED STATES LIGHT AND HEATING COMPANY'S SYSTEM

20 When the armature turns in either direction the friction of the commutator brushes causes the brush holders and brushes to change their position, so the polarity of the generator is preserved. This involves the use of a number of flexible wires and small parts, and changing the position of the brushes destroys the arc of contact with the commutator, causing excessive heating of commutator and parts. The United States system has two commutator brushes only; they are stationary and are not involved or disturbed when the polarity of the dynamo changes. The polarity changer, shown in Fig. 4 with the cover removed is applied to the end of the dynamo, and does not depend on friction for its operation, has no flexible wires, and is

positive and certain in its action. It is operated by a latch or dog fastened to the end of the armature shaft. This latch is brought in contact with a projecting ring on which are mounted substantial knife switches; the movement of the armature shaft in either direction causes the proper switch to be thrown. As the armature speed rises, the latch *A* is withdrawn by the centrifugal force created so that no wearing action takes place during the high car speeds. It adds no rotating shafts, bearings or worm gears found in other so-called automatic polarity changers, nor does it constantly require adjusting.

21 Par. 25 of Mr. Dixon's paper states that the most satisfactory illumination is obtained from center lamps of considerable power; and that a great number of small lamps is apt to make annoying shadows. Professor Shepardson of the University of Minnesota made photometer tests of about forty cars, gas, oil and electricity, and he says, "The great advantage of electric light is shown, as it comes first in point of uniformity, a result of using many lamps of small candle power instead of a few lamps of large candle power."

22 With the experience of past years, and the high degree of perfection reached by modern electric apparatus, electric lighting systems are not only as reliable and economical as any other system of lighting, but the absence of open flame and reduced fire risk makes it peculiarly adaptable to railway use and to all cases where uniformity of light is desired.

THE AUTHOR The alleged danger involved in the use of Pintsch gas lighting for railroad cars, as referred to by Mr. Brooks and others, does not exist. There are four times as many cars equipped with the Pintsch system of gas lighting as the entire rolling stock of the United States of America, and it has been in use on railroad cars more than forty years, and certainly the managers of railroads would not employ, to such an extent, a system of lighting which involves a serious hazard.

2 Electric light cannot claim freedom from hazard and applied to railroad cars has already caused much damage to rolling stock. Mr. Henderson recommends the use of an acetylene generator system, because of its availability for cars which do not reach central supply stations, and Mr. Brooks also refers to the desirability of electric lighting for such cars. A great many cars are now lighted by Pintsch gas which do not reach central supply plants. In some cases the gas is furnished by means of transport cars, and in other cases the gas is taken from one car to another without trouble or expense to the rail-

road company. Usually cars in branch line service require very small periods of light and pressures of one or two atmospheres are sufficient to supply them from two to four hours.

3 Mr. Flory in his discussion refers to the cost of mantles as being one properly chargeable to the expense of car lighting. That is true, but a comparison of the cost of mantle renewals and the cost of electric lamp renewals is as follows:

4 A car with six single Pintsch mantle lamps giving at least 500 candle power light, requires about eighteen mantles per year, which at a cost of 40 cents each is $7.20; but the cost of electric lamp renewals on a system operating more than one hundred and fifty cars, some with steam driven dynamos; some with storage battery and others with axle lighting system, averaged for the year 1906, $52 per car.

5 As to the cost of electric lighting methods, I refer to the paper written by Mr. O. W. Ott, and presented to the Western Railway Club, on "Electric Train Lighting," as being a very excellent description of the various systems, with reliable figures as to the cost of installation and operation. The costs are given in the following table:

COST ITEMS IN ELECTRIC LIGHTING SYSTEMS

	Head end system	Straight storage system	Axle dynamo system
Current cost	$145.21	$254.45	$127.70
Weight cost	37.87	63.46	81.82
Interest on investment	43.71	53.67	83.68
Depreciation on batteries	41.51	98.40	131.20
Depreciation on turbo-generator and fittings	11.25		
Depreciation on axle dynamos			67.00
Train electricians: attendance	156.25		
Yard electricians: attendance	34.19	114.06	45.62
Lamp renewals	29.18	9.32	29.18
Repairs	18.75	6.25	60.00
Oil and waste	10.26		5.13
Steam hose cost	5.00		
Total cost per car per year: operation	$533.18	$599.61	$631.33
First cost per car: equipment	874.25	1073.50	1673.50
Weight of equipment per car: pounds	2075	3800	4900

6 The actual cost of maintaining electric light on more than one hundred and fifty cars on a prominent railroad in the United States

during the year 1906 was found to average $524.90 per car and the average cost of equipment was $1344 each.

7 Mr. Henderson speaks of the cost of acetylene as being $7.50 per 1000. The results obtained on a large railroad in the United States, operating a compressed acetylene system, gave an average for four months of $11.30, to which should be added a fair amount for interest and depreciation on the plant, making a total cost of $12.93 per 1000 cu. ft.

8 The illuminating value of acetylene has been overstated. A one-quarter foot standard acetylene burner tip consumes from 0.426 to 0.461 cu. ft. per hour and gives from 10.75 to 12.16 c.p. A one-half foot tip burns from 0.576 to 0.650 cu. ft. per hour and gives from 18.2 to 19.98 c.p. A three-quarter foot tip burns from 0.664 to 0.733 cu. ft. per hour and gives 23.1 to 25.27 c.p. The highest efficiency or candle power per cubic foot is with a three-quarter foot tip, which gives an efficiency of about thirty-five candles per cubic foot. A one-quarter foot tip gives an efficiency of from 25 to 26 candles per cubic foot.

9 The relative costs of Pintsch and acetylene lighting have been obtained from a very careful determination made by one of the most prominent railroads in the United States. The costs were obtained from two months practically equal service of cars fitted with Pintsch mantles and acetylene, the latter being supplied by the generator system on cars. A careful record was made of the materials and labor used, and also of the hours of lighting service for each car. The actual illumination in candles feet was obtained for each sitting. The gas for the Pintsch system was purchased at the established selling price and the cost per car per hour with the Pintsch mantle system was seven cents, and with the acetylene system it was 10½ cents. The Pintsch mantle lamps gave an average of 1.03 candles feet while the acetylene gave 0.73 candles feet. For equal light the acetylene would have cost 15 cents, or two times as much as the cost of Pintsch lighting. Cars fitted with center lamps were found to be more satisfactorily lighted than those with side fixtures.

10 If the latest mantle lamps had been used the cost of gas would have been reduced one-third, reducing the total cost per car hour to 5½ cents.

THE STEAM PATH OF THE TURBINE

By Dr. C. P. Steinmetz, Published in March Proceedings

Prof. C. H. Peabody[1] That part of Dr. Steinmetz's article which deals with the path of steam in the turbine and the energy conversion is most interesting, and since diagrams like Fig. 3 and 4 are intended only to present the aspects of the problems to the eye, refinement is a minor consideration.

2 In approaching these applications of the theory of thermodynamics Dr. Steinmetz gives at length an approximate treatment of the subject based on the method that is proper for gases. When such an approximate method is presented it should be *a* shown that it is sufficiently accurate, and *b* that it is more convenient than the accepted method.

3 Under Par. 17 results of computations for the velocity of flow are given which allow us to test both these conditions.

4 I have recomputed the cases stated there using the accepted methods which can be represented by the following equations:

$$V = [32.2 \times 2 \times 778 \ (x_1r_1 + q_1 - x_2r_2 - q_2)]^{\frac{1}{2}}$$

$$x_2r_1 = T_2\left(\frac{r_1}{T_1} + \theta_1 - \theta_2\right)$$

The letters signify,

V velocity in feet per second,
r heat of vaporization B.t.u.
q heat of the liquid B.t.u.
T absolute temperature fahrenheit,
θ entropy.

4 The following table gives the data and results of Dr. Steinmetz's examples in English units:

Initial pressure	Final pressure	Velocity feet per second, standard method	Steinmetz's method	Error per cent
180	14.7	3022	2871	5.0
180	0.94	4068	3970	2.4
14.7	0.94	2932	2755	6.0

5 By the aid of the entropy table[2] the velocity can be determined very readily as can be seen from the following calculations of the

[1] Professor of Naval Architecture, Massachusetts Institute of Technology.
[2] Steam and entropy tables, Peabody. John Wiley & Sons.

above problems. The following table gives the required properties from the entropy table:

Pressure, pounds per square inch	Temperature, degrees fahrenheit	Heat contents $(xr + q)$ at entropy 1.56	Heat contents $(xr + q)$ at entropy 1.75
180.1	373	1201.0	
14.7	212	1018.0	1145.6
0.94	100	868.3	974.6

$$V = 223.9 \times \sqrt{183} = 3030.$$
$$V = 223.9 \times \sqrt{332.7} = 4084.$$
$$V = 223.9 \times \sqrt{171} = 2935.$$

6 The greatest discrepancy compared with my more exact computation is about three-fourths of 1 per cent; had interpolation been resorted to the work would be a little more, but the discrepancy would be reduced to a small fraction of a per cent.

7 There are some minor matters with which exception can be taken.

a In Par. 10 the specific heat of superheated steam is made to depend on the pressure only which does not accord with the experiments of Thomas and of Knoblauch.

b In Par. 20 the best velocity for a simple impulse wheel is asserted to be one half the velocity of the jet; this is correct only for certain relations of the angles of the nozzle and blades.

c In the next paragraph no allowance is made for centrifugal force which tends to increase the velocity of both jet and blades without limit; but this matter is really academic because no simple reaction turbines are made.

d It is to be desired that Dr. Steinmetz will report tests on nozzles giving from 97 to 98 per cent of the theoretical adiabatic velocity, because experiments by Stodola, Buchner and Rosenhain show a friction loss of 10 to 15 per cent which correspond to 0.95 to 0.92 of the adiabatic velocity.

8 It is difficult to understand why the whole discussion is presented in metric units when English units are now almost universally used in America and Great Britain and the conversion of equations into that system presents no difficulty.

Mr. Strickland L. Kneass Referring to the formulae used for governing the flow of steam through the nozzle, the paper opens with the equations of a perfect gas, and then states immediately afterward that these cannot be directly applied to steam. Par. 2 gives the basic empirical equations proposed and states that compared with accepted forms, they are the "most convenient for use, and at least as closely in agreement with the experimental data." The writer would like to ask Dr. Steinmetz if he has data to show any closer correspondence between his derived formulae and the actual velocities than the formulae given by accepted authorities.

2 Further, the value of a for adiabatic expansion is given as 1.126. Both Grashof and Zeuner state that a must vary with every mixture of water and steam, as well as with the initial and final pressures. For saturated steam it is given at 1.134 and varies from that value to 1.11, for 30 per cent of water. If the expansion follows the adiabatic law, it would appear that the value of the coefficient a may not be constant, as assumed by the author.

3 Par. 3 states that an exponential equation is preferred and considered more exact than that based on the "mechanical and the thermal-constants." Now the latter style of equation is less complex, the values can be taken from the steam tables, and the calculations are exceedingly simple to work out. The writer has used these formulae almost entirely for adiabatic expansion, and finds that they agree closely with the Rankine equations, and for the above reasons has preferred them.

4 Is it true that the flow of steam through a conducting or non-conducting nozzle is governed by the law of adiabatic expansion? Apparently Dr. Steinmetz accepts this theory in common with most authorities; yet there have been many experiments made during the last 15 years that tend to show that the velocity and resultant energy may be governed by a somewhat different law, which may correspond more closely to the formula for a perfect gas than to the thermodynamic equation. If the discharge of steam through a nozzle be examined critically, either by observation or by photography, it will be noticed that the issuing jet does not have the appearance of steam expanded adiabatically. In any form of nozzle, whether converging, diverging or even an orifice in a plate, the issuing jet is transparent. Suppose we take saturated steam from a reservoir at 120 lb. and discharge it into the atmosphere; if the steam expands adiabatically, there should be about 16 per cent of moisture in the issuing jet. It is well known that even if there be a comparatively

small per cent condensed during slow adiabatic expansion, the steam is cloudy, whereas the jet within and beyond a nozzle is transparent. Results of experiments have been presented before this Society where a thermo-electric couple was placed in a steam jet, and showed clearly an appreciable superheat within and beyond the

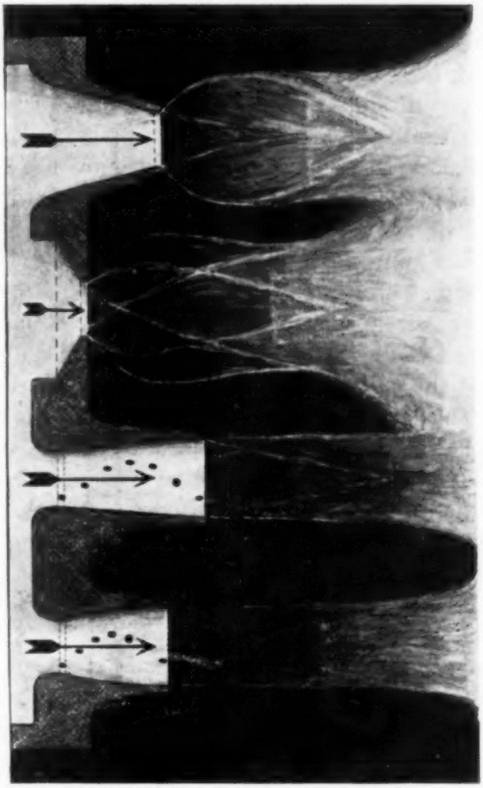

FIG. 1 ILLUSTRATION SHOWING THE APPEARANCE OF STEAM JETS DISCHARGING FROM NOZZLES AND MOUTHPIECES

nozzle, partly due to the friction among the particles of steam and partly to surface friction. It would therefore appear to be true that steam does not follow the adiabatic law during its free flow through a nozzle, for instead of partial liquefaction at reduced pressure, energy due to expansion is expended in agitating the particles of fluid and is reconverted into heat. Judging from tests at hand

by which the energy of the jet has been determined from the weight of steam discharged per second, and the pressure on a target so shaped that the line of motion of the particles of the jet was diverted 90 deg., the discrepancy is not large, but it exists. It is to be hoped that someone will make careful and refined tests to determine the actual variation. The nozzle must be proportioned for each initial and terminal pressure used.

5 The diagram shown in Fig. 1 illustrates several forms of nozzles and an aperture in a thin plate, discharging transparent jets under similar conditions of steam pressure and saturation and which are finally condensed into the usual white envelope of exhaust steam at the right hand side of the diagram. An attempt has been made to reproduce the photographs and a few words may be said in way of explanation: if we provide a background of black, the jets should appear white if an appreciable amount of steam is liquefied; or transparent, if the issuing steam is dry and superheated.

6 The upper nozzle is conoidal; the black background shows perfectly through the gaseous jet. There is a white line of surface condensation at the exit of the jet where it first comes into contact with the air. The expansion at the end of the nozzle is so rapid that the outer angle of discharge is nearly 45 deg. and the momentum of the particles expand the volume of the jet beyond atmospheric pressure, so that there is induced a subsequent contraction of the jet, due to the pressure of the atmosphere. There are, also, certain delicate lines of white moisture in the steam, which are apparently carried from the inside of the nozzle; the jet then disappears into a white cloud of condensation.

7 The form of discharge from the aperture in a thin plate is very similar, except that the expanded envelope and subsequent contraction are more marked. The third nozzle is the well known form of diverging nozzle having a ratio of 1.4 of the terminal to the minimum area. This nozzle is proportioned so that the internal pressure at the end of the nozzle shall be the same as the medium into which it discharges; the resultant jet is cylindrical. In these tests, a series of equi-distant holes was drilled in the nozzle and the pressure of the steam was determined during its flow through the nozzle. Based upon these experiments the writer published, in 1891,[1] some notes upon the curves of velocity and pressure which proved the advantage of the

[1] Experiments on the Discharge of Steam through Orifices, Proceedings, Engineers Club of Philadelphia, 1891.

correct ratio between the terminal and minimum cross sections for any given steam pressure, in order to obtain the full energy of the steam jet. The velocity at the minimum diameter of the nozzle was found as expected, to be practically constant for all pressures, so long as the terminal absolute pressure is not greater than 58 per cent of the initial. It was also noticed that if the internal pressure of the jet at the end of the nozzle exceeds that of the air, or final medium, it will expand laterally with loss of velocity; this is shown in the case of the conoidal nozzle. If the divergent flare of the nozzle be too great, the steam will expand below the pressure of the air and a contraction of the jet will occur immediately beyond the mouth.

8 The diagram gives a fair idea of typical forms of jets; also, that the steam flowing through and from a nozzle is transparent, and apparently, that it does not follow the law of adiabatic expansion. In view of the refined analysis by the author of the paper and his willingness to depart from accepted authorities, it is to be regretted that he has not included confirmatory data, nor taken up a newer line of investigation, which might include some of the points here raised.

NEW BOOKS

Members are invited to donate copies of their works to the Library. This is a custom generally followed by members of an association, and in the case of this Society, with its wide membership among technical writers, its observance would result in a considerable development of the up-to-date resources of the Library.

AUDEL'S GAS ENGINE MANUAL. A Practical Treatise Relating to Gas, Gasolene and Oil Engines, Marine Motors and Automobile Engines, including chapters on Producer Gas Plants and the Alcohol Motor. *Theo. Audel & Co. New York. 1908.* 8vo, cloth, 512 p., 156 drawings. Price, $2.

Contents by chapter headings: Historical Development; Laws of Permanent Gases; Theoretical Working Principles; Actual Working Cycles; Graphics of the Action of Gases; Indicator Diagrams of Engine Cycles; Indicator Diagrams of Gas Engines; Fuels and Explosive Mixtures; Gas Producer Systems; Compression, Ignition and Combustion; Design and Construction; Governing and Governors; Ignition and Igniters; Installation and Operation; Four-Cycle Horizontal Engines; Four-Cycle Vertical Engines; Four-Cycle Double-Acting Engines; Two-Cycle Engines; Foreign Engines; Oil Engines; Marine Engines; Testing; Instruments Used in Testing; Nature and Use of Lubricants; Hints on Management and Suggestions for Emergencies; the Automobile Motor; Useful Rules and Tables.

DESIGN AND CONSTRUCTION OF OIL ENGINES. By A. H. Goldingham. *Spon & Chamberlain. New York. 1904.* Cloth, 7½ by 5¼, 99 illustrations, xiii + 196 p. Price, $2.

Contents by chapter headings: Introductory; On Designing Oil Engines; Testing Engines; Cooling Water Tanks and Other Details; Oil Engines Driving Dynamos; Oil Engines Connected to Air-Compressors, Water-Pumps, etc.; Instructions for Running Oil Engines; Repairs; Oil Engine Troubles; Various Engines Described; Portable Engines; Large Sized Engines; Fuels; Miscellaneous.

(Presented by the author.)

THE GAS ENGINE IN PRINCIPLE AND PRACTICE. By A. H. Goldingham. *Gas Power Publishing Company. St. Joseph, Mich. 1907.* 8vo, cloth, 195 p. Price, $1.50.

Contents by chapter headings: Introductory—Historical—Theoretical—Losses—Ratings; Various Types of Engines—Comparison of the Two and Four-Cycle Types; Valves and Valve Motions; Governors—Igniters—Self-Starter and Other Details; Testing—Use of the Indicator and Brake—Representative Indicator Cards—Defects Shown by Indicator; The Use of Crude Oils, Fuel Oils, Distillate and Illuminating Oils, Vaporizers, etc.; Notes on Gas Producers and Gases; Installation—Utilization of Waste Heat; Operation and Correction.

(Presented by the author.)

FIELD SYSTEM. By Frank B. Gilbreth. *New York and Chicago. 1908.* 12mo, leather, 194 p. Price, $3.

Contents by chapter headings: "The Gilbreth Field System," by John P. Slack; General Outlines of Field System; Steady Pay Men; Orders; Brickwork; Scaffold; Duties of Engineers and Riggers; Rock Drills, Air Compressors; Boiler Fittings and Tools; Pumps.

(Presented by the author.)

Pocket-Book of Mechanical Engineers. By John W. Nystrom. *J. B. Lippincott & Co. Philadelphia. 1863.* 12mo, leather, 324 p.

(Presented by C. H. Foster, member of A.S.M.E., from the library of A. G. Goldthwait, deceased, member of A.S.M.E.)

A Manual of Elementary Geometrical Drawing. By S. Edward Warren. *John Wiley & Sons. New York. 1861.* 8vo, cloth, 105 p.

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Mechanic's Text-Book. By Thomas Kelt. *Phillips, Sampson & Co. Boston. 1857.* 8vo, cloth, 403 p.

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American Society of Civil Engineers. *Transactions. Vol. 59, 1907.* 8vo, one-half mor., 581 p. *Proceedings. Vol. 34, no. 2. February, 1908.* 8vo, paper, 199 p.

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Mining Institute of Scotland. *Transactions. Vol. 30, part II.* Also Supplemental paper. "Notes on some Tests and Results with an Oddie-Barclay High-Speed Mine Pump." 8vo, paper, 14 p.

North of England Institute of Mining and Mechanical Engineers. *Transactions. Vol. 58, part II. 1908.* 8vo, paper, 125 p.

West of Scotland Iron and Steel Institute. *Journal. Vol. 15, no. 1. October 1907.* 8vo, paper, 11 p.

National Association of Cotton Manufacturers. *Transactions. No. 83. 1907.* 8vo, boards, 300 p.

NEW EXCHANGES

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Patent Office (of Great Britain) Library Series. *1907. Bibliographical Series. Nos. 4, 6 to 15. 1901–1907.* 12mo, paper.

Public Service Journal. *The Stone & Webster Corporation. Boston.* Monthly 7 by 10.

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HANDBOOKS

Roper's Handbook of the Locomotive. 1874
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Alexander's Ready Reference and Key..............................1888
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TRANSACTIONS OF SOCIETIES

American Railway Master Mechanics' Association, 1872–1906, and Index.

Master Carbuilders Association. *Proceedings, 1867–1906.*

International Conference on Aerial Navigation. *Proceedings. Chicago. 1893.*

Institution of Mechanical Engineers. *1886, 1887 and 1889.*

American Society of Mechanical Engineers. *Transactions. Vol. II–XXVII. Proceedings. October, 1906–January, 1908.*

PERIODICALS

American Engineer and Railroad Journal. *1888 to date.*

Aeronautics. *Vol. I. 1893.*

The Railroad Gazette. *1870 to date. Vol. I to date.*

Eight Packages of Pamphlets and Photographs; 1 portrait, George Westinghouse; 1 portrait, Charles R. Johnson; 1 portrait, Howard Fay; 1 photograph, Baldwin Locomotive.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 15th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

06 Wanted, firm to manufacture patented gas engine on a royalty or will sell outright.

07 Junior member with patentable system of merit and wide application, would like to make equitable arrangement with small shop in New York or Brooklyn to have same built. Will require only small amount of capital.

MEN AVAILABLE

57 Junior, Lehigh graduate, three years general mechanical experience with large steel plant, two years in foreign country, surveying, foundation and track work. Would like to locate with consulting engineer or would consider offer as representative and salesman.

58 Mechanical engineer or assistant superintendent, familiar with modern shop methods and practice, interchangeable manufacturing and limit gages; can handle successfully all classes of labor. Location, California, Colorado or similar climate.

59 Mechanical engineer, junior, who has specialized for six years in the manufacture of sheet metal goods and has occupied position of general manager in a concern employing large number of men, can take complete charge of organization and is thoroughly posted on buying, selling, economic production, manufacturing costs, etc.

60 Technical graduate, age 32, twelve years broad successful experience as engineer of tests, designer, mechanical engineer and superintendent, desires position as adjunct or assistant in mechanical engineering department of recognized college or university, preferably, machine design, drawing or applied mechanics. Has had experience in teaching. Best references.

61 Mechanical engineer thoroughly experienced in gas engine and automobile design desires position as mechanical engineer or superintendent.

62 Member of the Society will be available for temporary engagement during the latter half of 1908. Can be of immediate service in executive work, calculation and design, testing and experimental work, inspection of boilers, engines, machinery, tools and supplies, mechanical engineering of power plants a specialty; speaks French and Spanish fluently.

63 Sales or advertising manager. Would like to correspond with a progressive manufacturer desirous of extending business at home or abroad. Thoroughly experienced in general business management, sales or publicity. Have recently returned from 18 months trip in European countries.

64 Position is desired as chief engineer or superintendent with a firm engaged in or taking up the manufacture of gasolene trucks; associate member four years continuous experience in this work, rising from draftsman to superintendent; technical education, executive ability, systematic, energetic. Available May 1; present salary $2100.

65 Technical graduate, four years practical experience, light and power stations, heating and ventilating, etc., general steam and mechanical engineering.

66 Member of the Society, who for a considerable number of years has been in charge of all of the mechanical design of construction in connection with the tunnel work of a railroad company located in New York City, is now open for engagement.

67 Manager, superintendent, or assistant; graduate Worcester Polytechnic; 18 years experience, design and manufacture of light and medium interchangeable machinery; plant construction and maintenance.

68 Cornell, M.E., now and since graduation abroad, acting as business manager and engineer for firm of engineers handling heavy machinery, desires position in the United States or Europe with exporting house.

69 Member desires position as engineer in charge of construction and maintenance of power plant or mill work. Cement mills a specialty; also familiar with high pressure hydraulic work, steam and electric work in general, blast furnaces, level and transit, foundations, concrete, structural and mechanical details.

70 Mechanical engineer with an extensive experience with progressive manufacturer at designing special machinery and tools. An expert on sheet metal working machinery and tools. Can handle a machine shop. Location, Central West.

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SMITH, Ephraim (1898), Colonial Steel Co., 84 High St., Boston, and 22 Shirley Ave., Winthrop Beach, Mass.

SMITH, Ernest L. (Junior, 1901), Repr., The Timken Roller Bearing Axle Co., Canton, O.

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